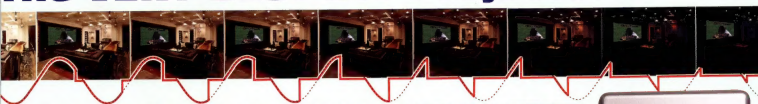
$9.95 W9
February 2
11 15 COV 5 230119
GG 10000939 995-000-003
SILICON CHIP

SILICON CHIP

FEBRUARY 2019
ISSN 1030-2662
02
9 771030 266001
PP255003/01272

The VERY BEST DIY Projects!

$9.95* NZ $12.90 INC GST



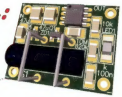
TRAILING EDGE DIMMER

With Touch Pad AND I/R Remote Control

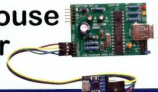
Handles:
- Dimmable LEDs
- Dimmable CFLs
- Dimmable Halogens
- even Incandescents!

More summer projects:

Motion Detecting 12V Power Switch



Keyboard & Mouse Adaptor for Micros

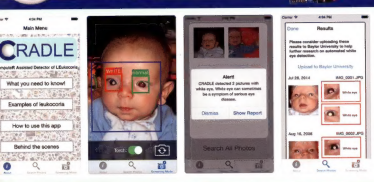


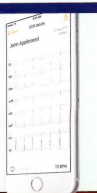
We review:

Philips "Brilliance" Ultrawide Monitor

Rigol MSO5345 Mixed Signal Oscilloscope

MEDICAL, HEALTH and FIRST AID APPS FOR YOUR SMARTPHONE



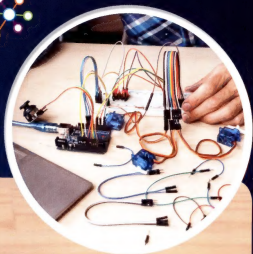


Building our new DAB+/FM/AM Tuner

awesome projects by **jaycar**

On sale 24 January to 23 February, 2019

Our very own specialists are developing fun and challenging Arduino® - compatible projects for you to build every month, with special prices exclusive to Nerd Perks Club Members.



project of the month: Benchtop Power Supply

A must have for every electronic enthusiast!

What better way to get back in to work than your own personal benchtop power supply. It can be used for testing small components like LEDs through to powering your Raspberry Pi at 5.1V, using an LM317 for power - providing from 2 - 30V with up to 1.5A of regulated current.

SKILL LEVEL: Intermediate
TOOLS: Soldering Iron, Drill, File

See step-by-step instructions at www.jaycar.com.au/benchtop-power-supply

1 × 3.5 Digit LED Panel Meter	QP5580	**$29.95**
1 × Add-On Board For Panel Meter	QP5575	**$9.95**
1 × Universal Pre-Punched Experimenters Boards	HP9552	**$6.95**
1 × Jiffy Box - 158 × 95 × 53mm	HB6011	**$4.45**
1 × Heatsink Compound - 10g tube	NM2010	**$3.95**
1 × LM317T +1.2 - 37V 1.5A Adjustable Voltage Regulator	ZV1615	**$2.95**
1 × SPDT Miniature Toggle Switch	ST0335	**$2.95**
1 × 5k Ohm Linear Single Gang (B) Potentiometer	RP7508	**$2.50**
1 × 7805 +5V 1A Voltage Regulator TO-220 case	ZV1505	**$1.85**
2 × TO-220 Heatsink	HH8516	**$1.55ea**
1 × 240 Ohm 0.5 Watt Metal Film Resistors - Pk8	RR0557	**55c**
2 × 10uF 25VDC Capacitor	RE6070	**35cea**
Plus your choice of sockets, knobs & switches		

NERD PERKS BUNDLE DEAL

$39.95

SAVE 40%

KIT VALUED AT $69.85

See other projects at www.jaycar.com.au/arduino

don't forget your essentials

ONLY **$5.95**

Test leads
Banana plugs to clip. 700mm long. WT5320

ONLY **$9.95**

30A current sensor module
Uses ACS712 hall effect sensor. Output ratio is 66mV/A. 31(L) × 13(W) × 15(H)mm. XC4610

ONLY **$29.95**

Switchmode mains adaptor 12VDC 2.5A
Extremely high power output for its size. 100-240VAC 50/60Hz. Supplied with 7 plugs. MP3490

ONLY **$43.95**

Breadboard - 1660 tie points
400 distribution holes / 1280 terminal holes. Mounted on a metal plate. 3 banana terminals. Rubber feet. 157(W) × 237(H)mm. PB8816

10% OFF* MAINS LAPTOP POWER SUPPLIES

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE & BE REWARDED WITH A $25 JAYCOINS GIFT CARD ONCE YOU REACH 500 POINTS!
Not a member?
Visit www.jaycar.com.au/nerdperks

*Terms & Conditions apply.

a better club is coming. keep being rewarded!

Check your email & contact details are correct In-store or online now. Don't miss out!

To order: phone 1800 022 888 or visit www.jaycar.com.au

Contents

Vol.32, No.2; February 2019

SILICON CHIP

www.siliconchip.com.au

Features & Reviews

14 Medical, Health and First Aid Smartphone Apps - Part 1

There's an enormous range of apps out there which allow your smartphone to do some pretty fancy diagnosis . . . or help your medical specialist treat your particular malady with vital, accurate data – by Dr David Maddison

30 Review: Rigol's MSO5354 Mixed Signal Oscilloscope

Tim Blythman takes a detailed "hands on" look at this latest model from Rigol (distributed by Emona). His verdict: "one we would definitely consider!"

35 El Cheapo Modules 22: Stepper Motor Drivers

Last month we explained in detail how stepper motors worked. Here are three low-cost stepper motor drivers that you can use – by Jim Rowe

88 Review: Philips "Brilliance" Ultrawide Monitor

When they say "brilliance" and "ultrawide", they're not exaggerating! It's almost as big as your desk, meaning you can have so many windows open at once! And the quality? As they say, "brilliance" – by Nicholas Vinen

Constructional Projects

20 Versatile Trailing Edge Dimmer with Touch Plate & IR

Most dimmers are "leading edge" meaning they're hopeless with most electronic lighting. Our new Trailing Edge Dimmer overcomes the problem – and gives you both touch plate AND infrared remote control! – by John Clarke

48 Motion-sensing 12V Power Switch

Designed for a specific task but then we realised just how useful this circuit could be! It's cheap, it's simple . . . but it works like a little beauty! – by Nicholas Vinen

68 USB Mouse and Keyboard Interface for Micros

Working with micros is fun – but how do you connect a USB mouse or keyboard to them? We solve that little problem with this one – by Tim Blythman

80 Our new DAB+ Tuner with FM *and* AM: Building it!

Last month we told you about our world-beating DAB+/FM/AM receiver. Has that caused some interest! Now the fun begins: putting it together – by Duraid Madina

Your Favourite Columns

42 Circuit Notebook

(1) Making a cheap WiFi controlled relay board work
(2) Modular quiz buzzer system
(3) Electret mic "crystal" set
(4) Four channel sound system using a single woofer

62 Serviceman's Log

(What) were the designers thinking? – by Dave Thompson

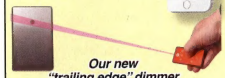
94 Vintage ~~Radio~~ Workbench

1970s BWD 216 Hybrid Bench Supply – by Ian Batty

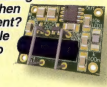
Everything Else!

2 Editorial Viewpoint
4 Mailbag – Your Feedback
61 Product Showcase
102 SILICON CHIP Online Shop
104 Ask SILICON CHIP
111 Market Centre
112 Advertising Index
112 Notes and Errata

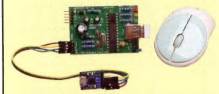
Own a smartphone? Take advantage of the huge range of Android and iPhone apps and add-ons available (and more coming all the time) to keep track of your health – Page 14



Our new "trailing edge" dimmer has no problems with dimmable LEDs, CFLs, etc – and you can control it with an IR remote or via a touch plate – Page 20



Ever wanted something to switch a 12V circuit on when it detects movement? Here's a cheap little project that will do exactly that! – Page 48



How DO you interface a keyboard or mouse to a micro? With this nifty USB Keyboard & Mouse Interface, that's how! – Page 68

We introduced our new world-beating DAB+/FM/AM receiver last month . . . now we get into the fun part: BUILDING IT! – Page 80

It's not just wide, it's ultrawide! The 49-inch curved Philips Brilliance 499PH1 is "strongly recommended" – Page 88

Find us on Facebook

www.facebook.com/siliconchipmagazine

SILICON CHIP
www.siliconchip.com.au

Editor Emeritus
Leo Simpson, B.Bus., FAICD

Publisher/Editor
Nicholas Vinen

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Jim Rowe, B.A., B.Sc
Bao Smith, B.Sc
Tim Blythman, B.E., B.Sc

Technical Contributor
Duraid Madina, B.Sc, M.Sc, PhD

Art Director & Production Manager
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Dave Thompson
David Maddison B.App.Sc. (Hons 1), PhD, Grad.Dip.Entr.Innov.
Geoff Graham
Associate Professor Graham Parslow
Ian Batty M.Ed.

Cartoonist
Brendan Akhurst

SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 626 922 870. ABN 20 880 526 923. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Subscription rates: $105.00 per year, post paid, in Australia.
For overseas rates, see our website or email silicon@siliconchip.com.au

Editorial office:
Unit 1 (up ramp), 234 Harbord Rd, Brookvale, NSW 2100.

Postal address: PO Box 139, Collaroy Beach, NSW 2097.

Phone (02) 9939 3295.

E-mail: silicon@siliconchip.com.au

ISSN 1030-2662

* Recommended & maximum price only.

Printing and Distribution:
bluestar
Derby Street, Silverwater, NSW 2148.

Editorial Viewpoint

Beware of dodgy and counterfeit electronics

It's bad enough that we are bombarded with so many scam e-mails, phone calls and letters these days. But you also need to be on the lookout for dodgy products.

Sometimes we order products from suppliers that we haven't dealt with before, either because we can't find them elsewhere or when there are delivery delays with our usual suppliers, only to receive either counterfeits or poorly-designed clones. Often, we pay the same for these dodgy parts as we would for the genuine articles.

For example, we purchased some batches of 74HC595 logic chips for our LED Christmas Tree kits (which were resoundingly popular). We ordered batches from different suppliers in case some of them were delayed, as we needed to get them in customers' hands well before Christmas, giving them time to build the trees.

Many of the chips we received were fine. But a couple of batches were faulty. And I don't just mean one or two chips; out of hundreds of chips, none of them worked. The dud chips came from at least two different suppliers but they all had the same date code etched in the top, along with a Texas Instruments logo. That certainly doesn't guarantee they were actually made by TI, though!

Their quality assurance (QA) process would have picked up a failed batch of chips and they would have been discarded. So either these chips were pilfered from the rubbish tip and sold to us, or they were counterfeits, brazenly etched with the TI logo.

Why someone would bother producing fake chips that are so cheap is a mystery to me.

Luckily, after complaints from customers over the first batch, we wised up and tested all the chips we received. And we were able to replace most of the first batch before they had been used. But it was still a huge hassle and we didn't get our money back from all the suppliers either.

So you really need to watch out for this sort of thing when you are buying electronic components from online marketplaces. Stick with the big-name suppliers where you can. You'll get what you pay for and if you do have a problem, you can ask for a refund.

You should also be aware that some of the "El Cheapo Modules" that we write about suffer from shady practices. When a module becomes very popular, clones are produced in large quantities and they are sold as if they are the genuine article. In many cases, the clones work fine but in others, they have design flaws or are poorly made.

The CP2102-based USB/serial modules are a good example. Some of the clones don't seem to have genuine CP2102 chips on them, as there is no etching on the top of the package. They work but the "3V3" output voltage is not correct, due to a PCB design flaw.

There are also plenty of clones of the popular BMP180 temperature/humidity module. Some have a mounting hole that's way too large but otherwise seem to work OK.

It's amazing what people will do to make a couple of dollars. You need to be vigilant when ordering from online marketplaces to make sure that you get what you pay for. Unfortunately, that's the flip side of the coin of these handy little electronics modules being so cheap.

And don't get me started on the wildly optimistic mAh ratings of so many 18650 Li-ion cells, jumpstarter packs, and the impossibly high lumen ratings of some high-powered LEDs...

Nicholas Vinen

7.5 MILLION+ PRODUCTS ONLINE | 750+ INDUSTRY-LEADING SUPPLIERS | 100% AUTHORIZED DISTRIBUTOR

Your Proven Source For the Components YOU Need In Stock for Immediate Shipment

AUSTRALIA
DIGIKEY.COM.AU
1800 285 719

NEW ZEALAND
DIGIKEY.CO.NZ
800 449 837

Australia: A shipping charge of $24.00 AUD will be billed on all orders of less than $60.00 AUD. A shipping charge of $20.00 USD will be billed on all orders of less than $50.00 USD. All orders are shipped via UPS, Federal Express, or DHL for delivery within 3–4 days (dependent on final destination). No handling fees. All prices are in Australian dollar or United States dollar. **New Zealand:** A shipping charge of $26.00 (NZD) will be billed on all orders of less than $66.00 (NZD). A shipping charge of $20.00 USD will be billed on all orders of less than $50.00 USD. All orders are shipped via UPS for delivery within 3–4 days (dependent on final destination). All prices are in New Zealand dollar or United States dollar. Digi-Key is an authorized distributor for all supplier partners. New product added daily. Digi-Key and Digi-Key Electronics are registered trademarks of Digi-Key Electronics in the U.S. and other countries. © 2019 Digi-Key Electronics, 701 Brooks Ave. South, Thief River Falls, MN 56701, USA

ecia MEMBER

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask Silicon Chip", "Circuit Notebook" and "Serviceman".

Helpful advice on finding and replacing failed SCRs

On pages 109-110 of the January 2019 issue, B. F. of East Malvern, Victoria asked for help regarding a replacement SCR for his sewing machine. You were helpful in providing a link to the service manual for the machine.

I have looked at the final page of the document in the link which contains the schematic and the only SCR visible is a low-power device labelled V2. All this does is drive the LED which indicates the oil level. Otherwise, the machine appears to be mostly pneumatic/hydraulic in operation.

Since B. F. gives no details other than it is a "low power" thyristor operating with a 24-30V supply, I suggest that he could use a 2N5061 (TO-92, 50V, 0.8A) to replace the original TAG 8706. This is available from Aztronics at: **siliconchip.com.au/link/aamk**

I can provide some help to M. R. who, in the same column, requested help to find an equivalent SCR to the 2N6170 in his Dunlite generator control system.

NTE show the NTE5566 as a possible equivalent to the 2N6170 and this can be purchased via Newark at: **siliconchip.com.au/link/aamn** For more details, see: **www.nteinc.com/Web_pgs/SCR3.php?a=12**

There are also a couple of RCA equivalents listed on eBay. They are not cheap but then neither are the alternatives. See the RCA T6420M at: **siliconchip.com.au/link/aaml** or the RCA S6420M at: **siliconchip.com.au/link/aamm**

Ross Herbert,
Carine, WA.

Bluetooth transmitter wanted for DAB+ radio

I'm very impressed with the DAB+/FM/AM Tuner design that you have just published. I hope to be able to build one, with most/all SMDs pre-mounted.

I don't know that my soldering skills/equipment are up to soldering SMDs, despite reading several articles on the appropriate techniques!

One suggestion I have for this project is to add the ability to connect, via Bluetooth, a speaker.

Given the ubiquity of these devices, it would appear to be more convenient than connecting it to a separate speaker unit via a cable. I would mainly be using the unit to take on holidays to keep abreast of the local and regional news and for background listening at home.

No doubt you'll be inundated with suggested improvements, some probably encompassing shortwave reception (I'd be keen on that also), but I hope that adding Bluetooth capability would be a reasonably easy exercise.

Many thanks for a great magazine.

Richard Bond,
Nunawading, Vic.

Response: you are right about the suggested improvements. At this stage, the only add-on that hasn't been suggested is one that dispenses tea or coffee!

Luckily, what you are after is quite easy to achieve. You just need to purchase a low-cost Bluetooth transmitter (typically less than $5) and connect it up to the line outputs using an RCA to 3.5mm jack plug cable.

They are usually powered from a USB supply so you could use a dual-output charger to run the radio and the Bluetooth transmitter.

If you need to integrate it with the radio, you can mount the Bluetooth transmitter inside the case using double-sided tape, cut short a USB cable and solder its red and black wires to the 5V supply rail on the radio board (or Explore 100) to power the transmitter.

A stereo audio cable with 3.5mm jack plug can then be cut short and soldered to the stereo line out solder pads to feed audio to the transmitter.

Using USB power banks in low-drain applications

I was planning to use a USB power bank to provide power for a small robot, as they are cheap, have a high capacity and provide a regulated 5V output. However, I have discovered an annoying feature of two of the power banks that I have.

I have a Bauhn power bank that I bought from Aldi some years ago. Its 5V output is enabled by pressing a button and remains active even with no load but the other two power banks are different.

They don't have power switches. The 5V output is enabled when a load is applied and if the load current drops below a certain level, switch off after a short time.

I had fitted the movement controller to the robot and was checking its operation using one of the other power banks when it stopped working. I had been testing the wheel motor operation and it was fine. But it stopped while I was checking the steering operation as there was very little load current.

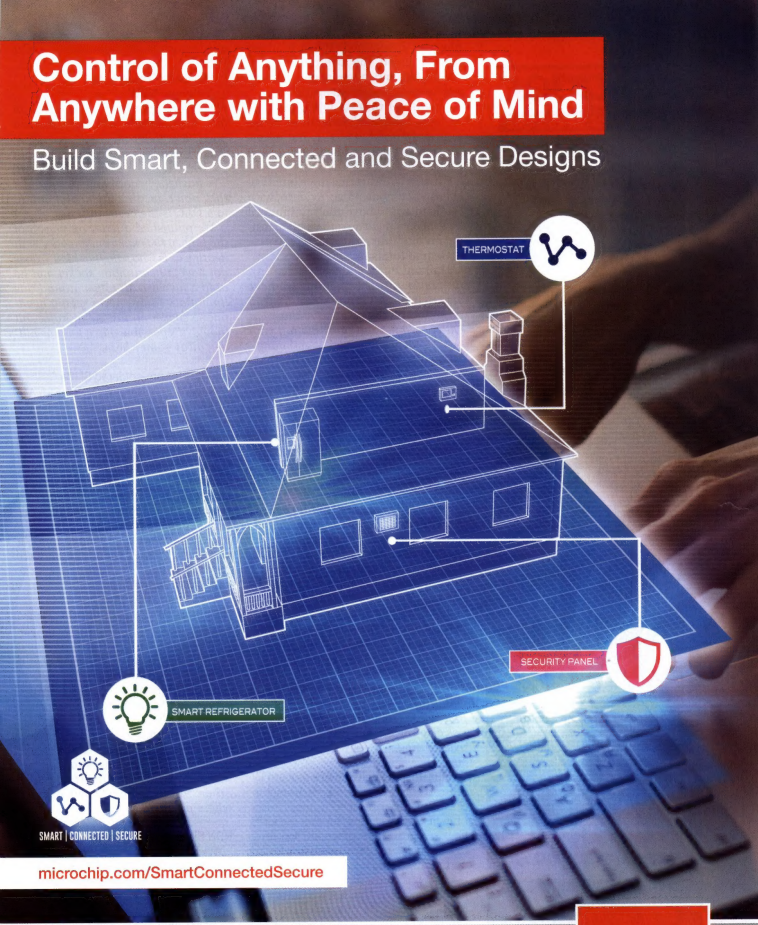
After some load testing of the power banks, I discovered that the minimum load current for the output to remain on varies from unit to unit, typically being around 50-100mA. Often, the output is enabled with a minimal loading at first but will not remain on for very long if the minimum load condition is not met.

It's a pity since the power banks provide a stabilised 5V supply using lithium batteries without the worries of designing for charging, over discharge, and short circuit protection. Also, spare power banks provide easy change-over when recharging is required. It's also easy to upgrade to a higher capacity unit. They all use the same USB plug. It is truly plug-and-play.

It is a pity that a minimum current

Control of Anything, From Anywhere with Peace of Mind

Build Smart, Connected and Secure Designs



microchip.com/SmartConnectedSecure

Contact Information
Microchip Technology Australia
Email: aust_nz.inquiry@microchip.com Phone: +61 (2) 9868-6733

MICROCHIP

The Microchip name and logo and the Microchip logo are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.
All other trademarks are the property of their registered owners. © 2019 Microchip Technology Inc. All rights reserved.

Wagner
ELECTRONICS SUPER STORE
OVER 40 THOUSAND PRODUCTS
ONLINE 1500+ PAGE CATALOGUE
AUSTRALIA WIDE SHIPPING

AUDIO/VISUAL ACCESSORIES
SPEAKERS / PRO AUDIO
ELECTRONIC COMPONENTS
DATA & ELECTRICAL
TOOLS & TEST EQUIPMENT
BATTERIES & MORE!
BUY ONLINE AT
WAGNERONLINE.COM.AU
VISIT OUR SYDNEY STORE
84-90 PARRAMATTA ROAD,
SUMMER HILL, NSW 2130
02 9798 9233

must be maintained. When a power bank turns off, the load must be disconnected and re-connected for the power bank to turn on again.

It will not turn on while the load remains connected. Even those banks with power-on buttons do not necessarily remain on unless there is a significant load on the output.

Finally, be aware that there is noticeable switchmode noise. Even so, with the load kept above the minimum, I have been able to do quite a bit of testing on the little robot.

George Ramsay,
Holland Park, Qld.

*Response: this is something we have also noticed. It's a pity since the USB power banks are so handy otherwise. One possible solution is to "roll your own" USB power bank by combining a LiPo battery pack bought from a hobby store with the Elecrow 1A charger board that we described in our August 2017 issue (**siliconchip.com.au/Article/10754**).*

That will provide an output of up to 1A at 5V with a manual power switch that won't be overridden and it's easily charged by plugging it into a USB charger or port.

You could connect multiple LiPo cells in parallel to make as big a battery as you need. It is a bit more expensive but it will do the job.

The only other solution we can think of would be to open up and modify the power bank to prevent it from switching off by itself but the required modifications will be different in each case and in some cases, it may not be possible.

For example, if the design uses a shunt to monitor the load current, you could increase the value of the shunt to lower the switch-off current (at the risk of lower efficiency and maybe even overheating).

Getting analog audio out of a modern TV

Browsing through recent issues of SILICON CHIP, I noticed a query from one of your readers in Ask SILICON CHIP, August 2018 (page 98), on how to connect a modern television to an audio amplifier.

I believe you will find that most, if not all, modern TVs have 3.5mm stereo headphone output sockets. These can be directly connected to most audio amplifiers via standard stereo jack plug to twin RCA audio cables.

Jaycar sells a cable which should meet your reader's requirements, Cat WA7014, for around $6.50.

Herman Nacinovich,
Gulgong, NSW.

Nicholas responds: you are right; in fact, we mention this very fact on page 96 of that same issue, regarding a query about using hearing aids with a smart TV. But as you suggest, not all TVs have the headphone socket and if they don't, feeding the digital output to a DAC is the best solution.

We published a letter on page 5 of the July 2015 issue from a reader with hearing aids who said that his TV does not have a headphone socket and he used a Jaycar DAC to get around this limitation. I have never seen a headphone socket on my TV at home, although it's possible that it has one hidden away somewhere.

Support for pre-soldered SMDs

Regarding your new DAB+/FM/AM tuner, please add my name to the list of people who are interested in buying the PCB with as many pre-soldered SMD components as possible.

I have never soldered an SMD device in my life, and with a slightly shaky hand, am not all that confident! Standard leaded components are OK for me to solder.

Over the years, I have built a number of SILICON CHIP projects, and all have worked first go.

Adrian Vermeulen.
Ferntree Gully, Vic.

Response: unfortunately, this board has too many components for it to be practical for us to fit them all but it will be much easier to build if you purchase the version with the most challenging components already in place. The remaining SMDs are much easier to work with.

This design would be impractical if we used through-hole components (they wouldn't fit, for a start) but we will undoubtedly continue to produce other through-hole based designs where practical.

NBN Fixed Wireless woes

We live in Dundathu, around 100km south-east of Bundaberg. So we're a little off the beaten path but not exactly out the back of Woop Woop.

It was only relatively recently that we were able to get ADSL1. That was a huge improvement over the satellite service that we had previously but the best speed we could get was around

Weller®

THE NEW WE1010 MODEL

GENUINE Weller® Approved tip quality

A name known around the world!

Weller®

- ✓ EASY TO USE
- ✓ COST-EFFICIENT
- ✓ FUNCTIONAL
- ✓ HIGH PERFORMANCE
- ✓ WORLD CLASS INNOVATION

6.5Mb/s download and 0.2Mb/s to 0.3Mb/s upload with a ping of around 33-34ms. But then we started having a lot of reliability and speed issues with our internet after our neighbour got ADSL too.

When the NBN was rolled out in our area, we were told by NBN that we could get fixed wireless. However, I knew that we were well out of range of the tower, which was located on the other side of a hill and only a few houses at the top of our street were able to receive this service.

After more than a year of NBN Co insisting that we could get NBN fixed wireless and me telling them that we couldn't, we decided that enough was enough and we ordered an NBN fixed wireless plan.

When the technician came to install the aerial, he said straight away that he doubted that we could get a strong enough signal here. I told him I already knew that.

He went to a lot of trouble trying to get a good signal from one end of the roof to the other and in all directions. He said that he needed a minimum of -99dB, but the best he could get was -110dB from the closest tower on the other side of the hill and -128dB from another tower in the other direction.

So finally, NBN Co had to accept the fact that we could not get NBN fixed wireless here. They should have listened to someone with local knowledge who knew what they were talking about!

No doubt the location of the NBN tower was chosen by someone behind a desk in Melbourne with no local knowledge; otherwise, it would have been more sensible to locate the tower on the hill where the coverage would have been a lot better.

Every NBN employee who came to our premises agreed with me that the location of the tower was inappropriate and it would have been better to be on the hill. Apparently, no consideration was given to reception in this area, when the tower location was set.

Then we started having a lot more problems with our ADSL. At one point, we had a ping of 10,682ms with a download speed of 0.003Mb/s and an upload speed of 0.001Mb/s. At other times, the internet was so bad that we couldn't even run a speed test, as it just came up with an error.

After multiple calls to our ISP, they finally fixed the line and now our internet is reliable most of the time. However, there are still times that the internet is unreliable or very slow, but this is less frequent than previously.

Our best ping is 33ms, our best download speed is 7.1Mb/s and our best upload speed is 0.4Mb/s. But most of the time it isn't quite that good.

Even a friend of ours who is on NBN FTTN can only get a download speed of around 8Mb/s, but his upload speed is 4Mb/s with a ping of 12ms. So much for the idea that NBN is going to revolutionise internet speeds here in Australia!

The current situation here is that we cannot get NBN internet and it doesn't look like we will be able to get ADSL2+ either. Two options are available to provide us with better internet service, but neither NBN or Telstra is prepared to undertake the necessary work involved.

The NBN main fibre cable runs past the park at the top of our street, so NBN could install a node in the park to provide us with NBN FTTN or Telstra could upgrade their RIM in the park to provide us with ADSL2+.

Either of these options would give us a download speed of at least 12Mb/s and an upload speed of over 1Mb/s and it would be a much more reliable service.

I wish that we could get the "lousy" 95Mb/s internet that Dave Thompson had (several upgrades ago) in Australia, because that would be a vast improvement on anything that we can get over here!

Bruce Pierson,
Dundathu, Qld.

Variations discovered in CP2102 USB/serial modules

You published my letter on page 6 of the October 2018 issue, where I mention that I found a design flaw in the CP2102 USB-to-serial converters in your Online Shop that causes the 3.3V output to sit at around 4.2V.

I have since discovered that some modules do output the correct 3.3V, so some manufacturers have picked up on the problem. This includes one of the modules I bought from your shop. I can see under magnification that the manufacturer has left out the track to the reset pin on the CP2102 IC, which solves the problem I mentioned before.

Your modules with the problem have no marking on the CP2102 IC and have HW-198 printed on the back of the PCB. The modules which operate correctly have nothing printed on the back and the IC appears to be a genuine CP2102 which is marked with that part number.

Peter Ihnat,
Wollongong, NSW.

Response: we will try to weed out these HW-198 modules from our stock. Unfortunately, it's hard to know whether we will be getting a genuine or clone version when we order them.

Not happy with lack of Banggood after-sales service

I am an ex-technical officer who has spent many years as a data analyst and am now returning to electronics. I have enjoyed your magazine for some time now.

I particularly enjoy hearing about the new items where small modules can now do the work of what would have taken a massive box of electronics when I first started ("El Cheapo Modules").

Banggood has generally been a particularly useful source and having read one of your articles about their DSO138 Digital Oscilloscope in your April 2017 issue (**siliconchip.com.au/Article/10613**), I bought one. Unfortunately, it arrived with minimal packaging and so one of the switches was broken as a result.

I have tried communicating with them twice. Sadly they haven't even had the courtesy to reply and so I will have to dispute the charge on my credit card.

This is a pity as my overall experience with both your magazine and Banggood (and similar suppliers) has been excellent and this situation is an anomaly. But sadly, the after-sales service of Banggood leaves a lot to be desired.

John Evans,
Macgregor, ACT.

Expandable Multi-channel Mixer design desired

I recently found out that my daughter was given an electric bass guitar from a friend. She had many lessons on the electric guitar when she was younger.

My first thought was to build her a mixer and an amplifier to suit the guitar. I found my reading glasses and went to look for some old magazines with suitable circuits.

When I was a teenager in the 70s, I

Join the Band

ORDER WITH CONFIDENCE | au.mouser.com

Purchase the products you know and trust from the distributor with the widest selection of electronic components in stock.

MOUSER ELECTRONICS
Authorized Distributor

australia@mouser.com

OCEAN CONTROLS
Helping to put you in Control

Ethernet & USB Multifunction DAQ
The T4 is a USB or Ethernet multifunction DAQ device with up to 12 analogue inputs or 16 digital I/O, 2 analog outputs (10-bit), and multiple digital counters/timers.
SKU: LAJ-027
Price: $315.00 ea + GST

Heating Cooling Controller
Multistage BACnet heating and cooling controller with backlight LCD display. 3 analogue 0..10V outputs, 2 digital outputs, 1 external auto-detect sensor, 1 digital input, built-in temperature sensor.
SKU: SXS-150
Price: $173.65 ea + GST

Split core current transducer
Split core hall effect current transducer presents a 4 to 20 mA DC signal representing the DC current flowing through a primary conductor. 0 to 200 A primary DC current range.
SKU: WES-063
Price: $119.95 ea + GST

Remote relay control across a LAN
Each TCW122B-RR is an Ethernet based I/O module that has two digital inputs and two relay outputs. Two units can be paired to seamlessly send digital IO data to the other over ethernet.
SKU: TCC-003
Price: $132.50 ea + GST

Digit Large Display
Large three digit universal process indicator accepts 4 to 20mA signal with confiqurable engineering units.
10cm High digits. 24V DC Powered.
SKU: DBI-020
Price:
$449.00 ea + GST

TxRail USB Non Isolated
DIN rail mount signal conditioner takes thermocouples, Pt100 sensors or 0 to 50 mV in and outputs 4 to 20 mA. Programable zero and span and 0-10V.
SKU: SIG-0021
Price: $94.95 ea + GST

Slim Analog Isolated Transmitter
Converts a 0 to 30 VDC signal to a 4 to 20 mA one with 1.5 kV isolation. Great for monitoring battery voltages etc.
SKU: AXB-090
Price: $169.00 ea + GST

For Wholesale prices
Contact Ocean Controls
Ph: (03) 9782 5882
oceancontrols.com.au
Prices are subject to change without notice.

built an ETI stage mixer with a couple of 100W amplifiers. But I couldn't find any suitable, modern designs. My next thought was to look at eBay for a guitar preamplifier but I couldn't find one with tone controls to suit a bass guitar.

So I would like to suggest that you publish a modular stage mixer design for young start-up bands and school kids. It could be based on microphone and hifi preamplifier modules that can be bought from eBay.

It would be fun to get young'uns interested in electronics by letting them put together what they need in any mix they seem fit. They might need to build something to mix all the separate outputs from all the boards together into a common output. They could also pick a ready-built amplifier to add to the project, with the power rating they can afford or need.

The whole lot could be built up like a massive stage mixer, or jam it into an old empty computer tower with the pots where the CD and DVD used to be and chuck in an MP3 player as well, if needed.

Some of the preamp boards that are commonly found on eBay are really inexpensive and would be easy to add as the "band" grows.

I am not looking for hifi quality, just something that's easy to assemble and does the job. The goal would be to build gear that they can use to make a lot of noise, with half decent sound quality, while they learn to play together.

The speakers can be a follow-on series, eg, 10-inch to 18-inch woofer with a tweeter in a stage box for lots of sound.

Michael Andersson,
via email.

Response: a modular mixer is a great idea but we have thought about this before and the difficulty is not the electronics, but the metalwork and cases.

Equipment used by bands tends to take a lot of abuse which means that the mixer would need a metal faceplate and probably a full metal case. And if it's expandable, that means a custom case that can be changed to suit a wide range of configurations.

It would be easy to build small electronic modules that could be linked together to form a mixer, and many beginners could successfully do so. But we can't see them cutting and machining large pieces of steel or aluminium, accurately drilling and cutting dozens upon dozens of holes and joining them together to make the strong case that would be required.

And while the eBay modules seem attractive, there's no guarantee if we pick one (or a few) to build a mixer around, that they will still be available by the time the article is published, or years later when someone may pick up the magazine and decide to build the mixer.

We have some ideas on how to get around these problems, eg, linking PCBs together to form the case, which would satisfy both the modularity requirement and also provide an easy way for us to get the case pieces premade with all the required cut-outs. But that would require a lot of smart design work to get right.

We'll continue to investigate the feasibility of such a design. In the meantime, you might consider building one of the guitar preamplifiers we have previously published, such as the two-channel guitar preamplifier with digital reverb from the November & December 2000 and January 2001 issues (siliconchip.com.au/Series/134).

Windows Update causing USB serial converter problems

Yesterday, my laptop undertook a Windows 10 update. It must have been a significant update as it took 90 minutes. After this, my CP2102-based USB/TTL converter (SILICON CHIP Cat SC3437) no longer worked.

I tried re-loading the driver in Device Manager but I got an error message indicating that it failed to install. I reverted to the previous version of Windows 10 (Version 1709, Build 16299.248) and the CP2102 USB/TTL converter operates fine.

I later discovered that downloading the driver from Silicon Labs' website (siliconchip.com.au/link/aalb) fixed this problem.

Gerard Lewis,
Wynn Vale, SA.

Getting custom speaker boxes made

I thought your readers might like to see the custom three-way speaker boxes which were made by my local cabinet maker, shown in the supplied photo. One $60 sheet of 20mm thick craft wood is cut into the pieces needed to build six pairs of speakers in about 10 to 15 minutes.

Gluing the pieces takes less than five minutes per speaker once you

have some practice and the only additional cost apart from the amplifier and drivers is paint.

I was quoted $60 each to coat the boxes with two-pack but that is outside my budget, so I painted them myself. I've also lined the cabinets with acoustic foam and the design includes a tuned port.

I have incorporated into each pair of speakers a Dayton Audio KAB-250 2 x 50W Class-D audio amplifier with Bluetooth support and the ability to run from a Li-ion battery. I got those from Wagner (WES).

I have built suitable passive crossovers into each speaker too. The amp is in one speaker box and connects to the other via a cable. The amplifier runs off a 5A switchmode power supply.

I also included a Li-ion rechargeable battery into the cabinet with the amplifier, so that the speakers can be run away from mains power for several hours. It's recharged by the same power supply.

I find the resulting sound quality to be very good. I have completed five stereo sets and sold two, both going to teenage girls who gave me positive feedback. Both fathers are reportedly jealous!

I have built several speaker kits over the last 20 years but I most of them cost a lot more to put together than this design. I am particularly happy with the KAB-250 amplifiers.

You can get more information on the KAB-250 amplifier module from WES at: siliconchip.com.au/link/aamj

Phil Prickett,
Walkervale, Qld.

New balanced microphone preamp wanted

You haven't published a balanced microphone preamplifier project since 2004. Integrated circuits for state-of-the-art audio projects have improved *enormously* since that 2004 SILICON CHIP design!

I have a $600 true capacitor performance microphone, plus a new SE V7 aluminium voice coil state-of-the-art dynamic performance microphone, so I need to build a new balanced mic preamp.

So how about a new design at the current state-of-the-art? If anyone can do an up-to-the-minute balanced microphone preamp project, it will be SILICON CHIP. It will be another feather in SILICON CHIP's already heavily-feathered cap!

So come on Guys, don't keep me and all the others who need and would greatly appreciate such a project waiting any longer. Just get to it!

Otto Van DeZiel,
Alderley, Qld.

Response: we think the idea of a revised balanced microphone preamp is a good one, but not because audio ICs have improved enormously since 2004.

In fact, we would argue that they have changed very little. Some of the vaunted new whiz-bang audio ICs like the LM4562/LME49710 turned out to be disappointments, giving worse distortion (measured using multiple Audio Precision sets) than the venerable NE5532/NE5534 in any circuit that we swapped them into.

If we were to design the ultimate microphone preamp using current technology, it would almost certainly use discrete transistors for the front end.

Using the right transistors, it is possible to achieve better signal-to-noise ratios than even very expensive op amps can. The good old NE5532 is more than good enough for the final gain stage.

By the way, we have published at least two balanced mic preamps since 2004. There is John Clarke's Microphone preamp for PCs & MP3 players in the July 2008 issue and the Lump-in-the-Coax Mini Audio Mixer

in the June 2013 issue which incorporates a balance microphone input.

Admittedly, the latter one is not hifi; after all, it is a portable, battery-powered unit.

Pool safety for kids

I recently saw an article on the website **http://slashdot.org** with the heading "Engineer Develops Sonar Alarm System To Monitor Kids In the Pool" (**siliconchip.com.au/link/aamp**). According to the article:

"When small children who have no business going into the pool on their own are out playing near it, they wear a special wristband. If they should fall in, the wristband will generate a three-tone sonar signal as soon as it's immersed in the water.

That signal will be detected by a hydrophone contained within a receiver unit that floats in the pool. When that happens, the unit will emit a 131-decibel alarm."

I remember that you published something similar many years ago. That just goes to show that you are often way ahead of the curve! Keep up the great work.

Dr Lewis Williams,
Chifley, NSW.

*Response: you are right, our Swimming Pool Alarm project was published in the September 2000 issue (**siliconchip.com.au/Article/4296**)! We still think that was a great idea and it could still be built today.*

It's intended to warn you if a child gets into an unattended pool, which is a slightly different situation than you described, but still a very serious one.

We note that pool fencing laws are much more strict now than they were back in 2000, no doubt due to many tragedies since.

It seems a bit impractical to fit each child at risk with a wristband, but if there are already other people in the pool, there would need to be some way to distinguish them.

Electric shock hazard from water taps

I just saw a story on the ABC News website – the family of the 11-year-old girl who received a severe electric shock from a home water tap in March will receive $1 million in compensation from the government. See: **siliconchip.com.au/link/aamo**

Perhaps you can suggest a way that readers can establish if their home taps are safe or not.

Dr David Maddison,
Toorak, Vic.

*Response: we mentioned this tragedy on page 7 of the May 2018 issue and it is not the first time we have warned that domestic water taps can be a shock hazard. We ran an article titled "Your House Water Pipes Could Electrocute You" by Leo Simpson in the August 2014 issue (**siliconchip.com.au/Article/7966**).*

That August 2014 article explained how to check whether your water pipes are safe. Basically, you turn on a large appliance in your home, that will draw around 10A, but leave everything else switched off.

Then you use a clamp meter to measure the current flowing through the pipe to/from your water meter. If you get a reading above 5A, that suggests your Earth stake is not doing a good enough job.

It would also be a good idea, at the same time, to use a multimeter set to measure AC volts between any exposed water pipes on the outside of your home and a known-good Earth; preferably, a 1m+ metal stake pushed into damp soil. You should get a very low reading; no more than a few volts. Any more is a cause for concern.

The real danger, though, is that if your Earth wiring or stake has severe corrosion, it could measure OK today but be dangerous tomorrow when the final strand corrodes through. So it's wise to regularly inspect your electrical wiring and Earth stake and repair/replace either at the first sign of corrosion or damage.

In our opinion, electrical authorities are too cavalier when it comes to nipping these problems in the bud. Back in 2014, Leo measured very large currents flowing through his pipes, and those of his neighbours, and he reported this to the relevant authorities. But since there did not seem to be an immediate hazard, they said that there was nothing they could do about it.

The problem with that attitude is that eventually it could become a hazard and the first sign could be when another person gets a severe electric shock. Addressing the root cause then would be a case of closing the stable doors after the horse has bolted.

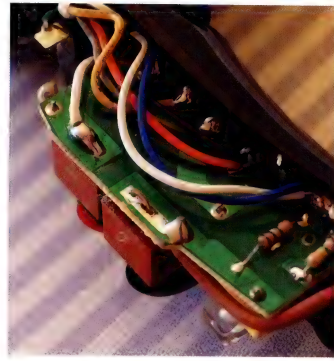
Very poor soldering in consumer equipment

I have written letters to you before about appliances with bad terminations, for example, bedside lamps with the arcing switch that my grandson found.

Now I have a story about my wife's hair dryer which she had been using daily for 4-5 years. I know that these things are not expensive, so they are effectively considered disposable.

Recently she yelled out that it was giving out a strong burning smell and the handle was hot to touch. See the attached photo of the poor soldering connections. There are several dubious joints, including where the mains Active wire is connected to the board and on the adjoining switch tag.

I think these joints are so bad that they must have a high resistance and have started heating up excessively, leading to the bad smell and hot handle.



I would surmise that the board is assembled separately, then the wiring is attached to finish it off. It appears that at no point did anybody notice the atrociously bad solder joints.

Suffice to say, I re-soldered them, tested the dryer and gave it back to the wife. It still smells a bit but the handle does not get hot anymore.

To top that off, I purchased some solar garden lights for $9 each. They have a switch to change from white light to cycling red/green/blue. A nice Christmas effect, I suppose, to make the family happy.

On one of the five lights I purchased, the white LED lit up regardless of the switch position. So in one position, it gave white light only and in the other position, cycling colours as well as white.

I undid three screws to open it up and found that two of the wires soldered to the switch had been over-stripped and both were too long. This resulted in the wires shorting to the switch's metal body. So I snipped off the excess length of both and the solar light performed as intended.

Brian Collath,
Moss Vale, NSW.

Response: while PCBs are often assembled by machines, wires like that would usually be soldered by hand, along with any large through-hole components.

Those solder joints are shocking. Some of them almost look like they were missed entirely. It's as if the person doing the job gave up halfway through.

It's an odd design. They have surface-mounted through-hole components as if fitting those components was an afterthought, although it may actually be a space-saving (or cost-saving) measure.

Photovoltaic boosting for hot water systems

I have been researching the plethora of so-called MPPT photovoltaic (PV) direct water heaters and found them to all be quite expensive, yet some of the circuits I see incorporate well under $100 of components.

I would like to see you publish a project covering a PV-powered immersion heater (not just a solar diverter) of at least 1kW. Four 250W panels are very affordable these days.

Currently, I am using such a controller from Techluck which cost just under $400. It is fitted to my 400L hot water tank with 1kW of panels and a 4.5kW heating element. I notice on average that it seems to be able to hold 25°C on cloudy days, and up around 35°C+ on sunny days.

I want to build a higher output system and possibly build a couple more to help keep my pool warmer and offset my heat pump usage.

Apparently, some smart people are using PV panels to power in-slab electric heating, saving thousands of dollars yearly.

Adam Aitken,
via email.

Response: that is an intriguing idea but it would require a lot of time and money for research, development and testing. It might also require some serious hardware, given that you're talking about multiple kilowatts of heating power.

You should also consider whether it would be more economical to use the same number of PV panels to offset home electricity usage instead and use LPG or natural gas for the hot water. SC

AUSTRALIAN DESIGN AND MANUFACTURE SECURES YOUR IP

- Product design
- Product development
- Software development
- Small scale manufacture
- Equipment repair
- Obsolescence related redesign
- Environmental testing
- Open-air test site
- Data recovery
- Emission analysis
- Secure facility
- Extensive existing product range
- Secure data
- Secure voice
- Covert/LPI communications
- Surveillance products
- Fibre optic

CYPHER RESEARCH LABORATORIES

U7-10/21 Johnson St, Cairns
Phone: +61 7 4058 2022
Email: enquiry@cypher.com.au

VISIT: www.cypher.com.au

You asked for it . . .
We've Delivered!

Over 265 Articles from April '97 right up to date!

The Vintage Radio Collection from the pages of SILICON CHIP

"Vintage Radio" is one of the most popular columns which appears every month in Australia's most-read and authoritative electronics magazine, SILICON CHIP.

Over the years many readers have asked us if there was a single source for all "Vintage Radio" articles so a particular set or sets they have managed to get hold of could be referenced. Until now, that was not possible.

But now it is!

We've put together a DVD containing every "Vintage Radio" column for more than 20 years – from April 1997 right through to December 2018 – and included an easy-to-read index so you can find the one you're looking for.

They're all provided in PDF format so the quality is even better than in the magazine (you can actually read many dials!). And there's much more than radios – there's articles on vintage TVs, amplifiers... all from a bygone era!

Physical DVD:	As seen above
In paper sleeve	– $55
In deluxe case	– $60
(Plus $10 p&p within Australia)	

Downloaded copy – $50

#To view, requires Adobe Acrobat on your computer (free to download): https://get.adobe.com/reader/
Cannot be used with an audio DVD Player

Exclusively available from SILICON CHIP: www.siliconchip.com.au/shop

Medical Diagnosis and Monitoring via Smartphone

There have been many recent, exciting developments in medicine which take advantage of the power and ubiquity of the smartphone. This puts powerful diagnostic techniques in the hands of practitioners in the field, or in many cases, patients themselves. Tests which used to take weeks can now be done in minutes, very cheaply. Here are just some of the latest in smartphone-based medical technology.

Part 1 – by Dr David Maddison

As the cost of medical care continues to rise, the pressure to reduce costs is mounting. There is also a desire to monitor the patient's well-being on a continuous basis.

One way to reduce cost is to reduce or eliminate the need for patients to visit medical centres for routine tests.

If the patient had a suitable testing device, they could perform the test themselves and transmit the results to a medical specialist for evaluation and diagnosis.

This would also allow the patient's condition to be monitored on a regular or even continuous basis.

Fortunately, today, most people carry with them most of the technology needed to achieve this, probably without realising it.

It's a device which contains a powerful computer and communications system to process and transmit information to a diagnostician. Of course, we're talking about a smartphone.

In some cases, it doesn't even need any added hardware; the onboard camera, microphone and other sensors such as accelerometers can be used to monitor the patient.

Over time, smartphones tend to incorporate more and more sensors. There is no reason either why sensors already in separate handheld devices could not be incorporated into a phone.

One example is a breath alcohol meter; relatively easily incorporated in a smartphone, it would allow the user to check that they are beneath the legal blood alcohol level before driving.

But it could also be useful for many medical purposes.

Smartphone medical diagnostic apps can be split into two types: those which use the phone's inbuilt capabilities, and those which require

Fig.1: the Miiskin app is used to document changes in skin lesions, rather than make diagnoses.

the addition of a peripheral device to perform a function that the smartphone is not intrinsically capable of (possibly in conjunction with other onboard sensors).

Examples of the former, described in more detail below, include those which can diagnose an eye condition by imaging the eye directly, while others can read the result of a medical test by sensing the colour that a specially treated paper turns after being exposed to the patient's blood, saliva etc.

Examples in the second category include as a peripheral to detect specific chemical compounds in the patient's breath which are indicative of disease, and microscope attachments to observe bacteria or genetic markers.

Some of the technologies described in this article are already available for use while others are still under development. The technologies described here are only a subset of the hundreds that already exist or are under development.

Detecting skin cancers

Some years ago, a number of skin specialists set up clinics to photograph your body and compare it with new images taken, say, six months or a year later. Changes in the images automatically flagged information for the specialist to further investigate.

While there are still a few of these centres around, they have largely been overtaken by the camera and apps built into smartphones.

These apps are now being used to diagnose and document changes in possible skin cancers or pre-cancers.

There are at least 26 such apps and while they could be very useful for people living in remote areas, they should not replace regular GP or skin cancer specialist visits.

There are also some ethical and other concerns with using these types of apps, which are described in an article at Bioengineering Today: **siliconchip.com.au/link/aamf**

Some of these skin cancer recording and/or diagnostic apps are as follows:

Miiskin (**https://miiskin.com/**) does not attempt to make a diagnosis but is simply a tool for documenting the changes in skin spots over time, as described above (Fig.1).

UMSkinCheck (**www.uofmhealth.org/patient+and+visitor+guide/my-skin-check-app**) from the University of Michigan (USA) is another example of a skin cancer app that is used to document changes in possible skin cancer lesions (Fig.2).

With **SkinVision** (**www.skinvision.com/**), a smartphone is used to take a picture of a suspicious skin spot. It uses a combination of machine learning and in-house dermatologists for diagnosis.

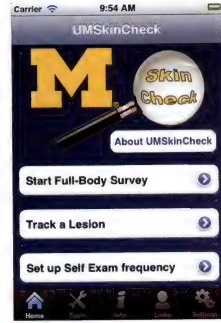


Fig.2: screen grab from the UMSkinCheck app.

If the software determines that a spot is a high risk for cancer, it is reviewed by a dermatologist (Fig.3).

For a scholarly discussion of these apps, see the abstract at: **www.ncbi.nlm.nih.gov/pubmed/29292506**

DermLite (**https://dermlite.com/products/dermlite-hud**) uses a supplemental rechargeable magnifier that uses polarised light in conjunction with the smartphone camera. The

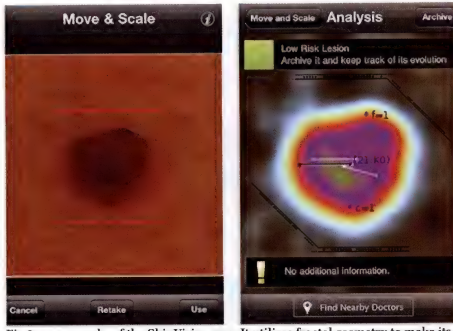


Fig.3: screen grabs of the SkinVision app. It utilises fractal geometry to make its assessment.

Medical monitoring apps and devices you may already be using

Without realising it, you may already have used apps that could be considered medical in nature.

With today's emphasis on keeping fit, there is a plethora of apps out there for use on smartphones to monitor excercise, heart rate, etc. Others use an app to record what goes in – their food, etc.

For example, many people use **MyNetDiary** (app only) to track their diet, a **FitBit** (app and hardware) to track exercise and **WakeMate** (app and peripheral, out of production) to monitor sleep patterns.

device is used to make high-quality photographs of suspicious lesions, so that one can share them with one's dermatologist for review (Fig.4).

Incidentally, at least some of these apps are available to download free of charge – if they ask you for your phone number, don't forget it should be in international format (eg, for Australia, 61401234567).

Diabetes monitoring

There are numerous apps available to allow diabetic patients to manage their condition by recording what they eat and so on, as well as blood glucose levels. However, most of these require manual entry of test data.

We'll look at some of these in a moment.

But there was also an app announcement, in August 2017, from Epic Health (https://epichealth.io/), which is said to be able to use the smartphone

Fig.4: the DermLite HUD peripheral for photographing suspicious lesions.

camera to check glucose levels.

The app was said to work by having a patient place their finger directly on the smartphone camera and the image is sent to a remote computer for analysis, to determine blood glucose levels based on the patient's blood flow.

However, as of the time of writing, there have been no further announcements on this app and we are somewhat sceptical that this scheme will turn out to be reliable.

By contrast, there are Diabetes-monitoring apps which are already in widespread use but they use more invasive techniques, eg, a patch with a tiny needle going into the patient's body, communicating with the phone via Bluetooth.

That's hardly surprising, given the number of people suffering from (especially) type 2 diabetes – estimated at around 1.2 million in Australia alone and a whopping 422 million worldwide – up by more than 300 million in the past 3 years.

Most diabetics monitor their blood sugars manually, using a droplet of blood on dedicated (one-use only) test strip on a blood glucose meter.

However, one recently introduced system is the Freestyle Libre from Abbott Laboratories (www.freestylelibre.com.au) – see Figs.5 & 6.

It sends data from a tiny needle in a patch worn (usually) on the arm. This automatically transmits readings to a special blood glucose meter which can then transmit the stored data (up to 90 days worth) to an Android or iPhone via another app.

This is claimed to be especially useful for parents and caregivers who can monitor blood glucose levels "on the go".

These have been widely promoted recently but it would appear the major reason for lack of acceptance in the diabetic community is, quite simply, their cost, compared to the more traditional blood glucose meters and test strips.

(The patch system is not [yet?] subsidised by the Government – ie, on the PBS) whereas use-once test strips are on the PBS)

There are yet other diabetes apps which mate with the traditional blood glucose and/or ketone meters that all diabetics know.

We've seen a couple of these which automatically (or manually) transmit the meter's readings to a smartphone.

This has a possible three-way benefit – (a) it saves the diabetic patient from having to transfer their readings to a diary; (b) the readings can be automatically forwarded on to the patient's specialist, and (c) some are said to be capable of warning the patient where there are significant changes in readings – especially ketones.

The one thing that they don't do is save the patient from pricking a finger up to several times a day to obtain blood

Fig.5: the Freestyle Libre system continuously monitors blood sugar levels via a "patch" worn on the body, which transmits data to the blood glucose meter. It can then send data to a mobile phone via the LibreLinkUp app, as shown in Fig.6, right.

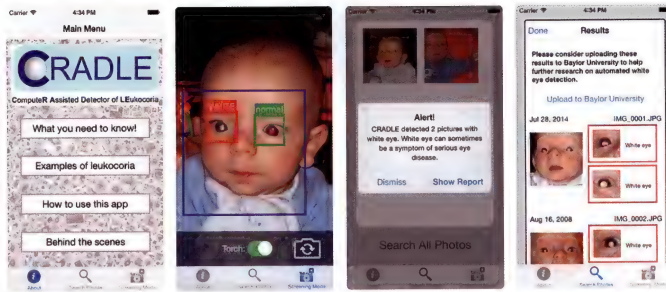


Fig.7: the free CRADLE app for iPhone and Android devices, to detect leukocoria from photographs.

samples for the meter to analyse (the part that diabetics universally hate!).

Diagnosing eye disease

A smartphone's inbuilt camera can be used to diagnose eye problems.

While "red eye" is a technical problem that many photographers experience, it's not indicative of any health problems (it's caused by the camera's flash light reflecting off the retina inside the eye. Many cameras "double flash" to make the eye's iris close down on the first flash and take the photo itself on the second flash).

However, so-called "white eye" or leukocoria as seen in photos of both children and adults can be a sign of an underlying condition. Immediate medical attention should be sought if this is noticed.

And once again, there is a high probability that in not-too-distant future, a smartphone camera could capture and compare images of the back of the eye to detect the early stages of diabetic neuropathy – a quite common and relatively serious effect of diabetic damage.

There is also the possibility of smartphone apps being developed for early diagnoses of cataracts, glaucoma, tunnel vision (retinitis pigmentosa) and other eye disorders.

An app called CRADLE assists in detecting early forms of some eye diseases, although it is no substitute for an examination by a medical professional. For more information, see: https://cs.baylor.edu/~hamerly/leuko/

Monitoring Parkinson's disease symptoms

Parkinson's disease results in tremors, stiffness and slow movements. It is caused by a shortage of the neurotransmitter dopamine and its symptoms can vary widely.

Patients are typically assessed by a specialist a few times a year, but these tests are largely subjective and Parkinson's symptoms are known to vary drastically over time.

For improved symptom assessment, it is important to monitor symptoms much more frequently and using more objective criteria.

mPower (https://parkinsonmpower.org/) is a "mobile Parkinson's observatory for worldwide, evidence-based research".

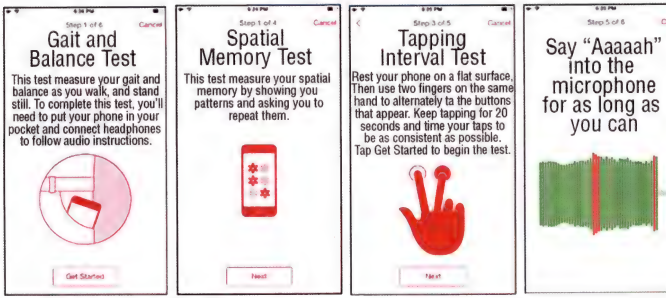


Fig.8: some sample screens from Sage Bionetworks mPower app for Parkinson's disease sufferers.

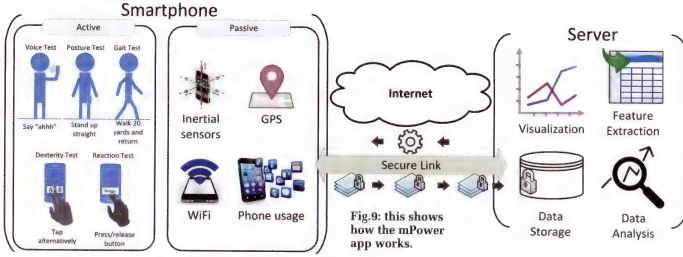


Fig.9: this shows how the mPower app works.

It is an iOS app designed by Johns Hopkins University and the non-profit organisation Sage Bionetworks (see Figs.8 & 9).

The purpose of this app is to participate in a study which allows patients to monitor the progress of their condition on a regular basis, rather than infrequently by medical appointments. Parameters such as gait and balance, spatial memory, finger tapping and walking can be monitored.

Data can also be acquired from wearable devices. The patients also have the option to "donate" their data to researchers.

Early insights into the disease made by researchers using this data include severity of symptoms as a function of time of day and responses to exercise or treatment. The higher frequency at which data is collected leads to new insights into the disease.

Note that only people who live in the USA are currently eligible to participate in this study but there are plans to extend it to other countries.

You can view a YouTube video playlist with instructions for the various tests in the HopkinsPD app, the predecessor of mPower, at: **siliconchip.com.au/link/aamh**

Using a smartphone for remote diagnosis

Sana (**http://sana.mit.edu/**) is a system intended primarily for use in less developed countries.

It provides a smartphone-based platform for communications between a healthcare worker in the field and a remote clinician for remote disease diagnosis and data storage (Fig.10).

According to Sana, they use technology to "overcome resource limitations, focusing on analytics to drive evidence-based quality improvement, and an educational program for capacity building to promote locally sustained innovation" in health care.

There are various similar projects underway in Haiti, India, Lebanon, Mexico, Philippines, Uganda among other places. See the video titled *"Mobile Medical Diagnostics"* at: **https://youtu.be/h-Zz5a6ARsQ**

Smartphone apps for clinical trials and epidemiology

Patients undergoing clinical trials with new drugs are often asked to use a smartphone app on a daily basis to self-assess their symptoms, by rating the severity of their condition on a numeric scale.

This data is used to determine if there has been an improvement in their condition due to the experimental drug, side effects and so on.

Similarly, field health workers (especially in Third World countries) can use smartphone apps to log incidences of disease outbreaks (such as Ebola) into a central database, so their spread can be tracked by authorities.

Diagnosis with a smartphone and a passive device

In some cases, a smartphone app is paired with a passive device like a skin patch, to perform diagnoses which are not possible with the phone alone

We're referring to these devices as passive since they don't contain electronics. apps that use external electronics hardware will be described later.

Bacticount

Bacticount (**http://bacticount.com/**) is a free, open-source diagnostic sys-

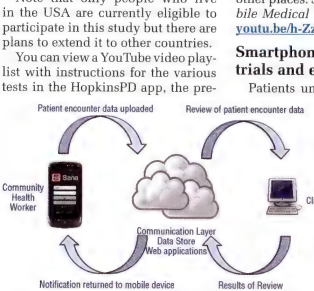


Fig.10: the Sana app concept, showing communications between a field worker and clinician and also the intermediate data storage.

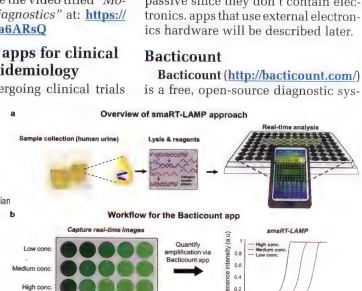


Fig.11: the Bacticount methodology.

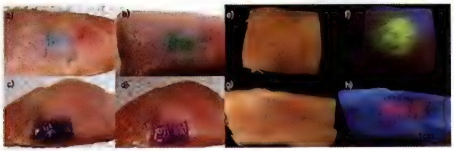


Fig.12: a series of Biosensors tattooed on pig skin for testing. Top row, from left (a and b) show a glucose biosensor without and with glucose; bottom row, from left (c and d) show a biosensor at pH 7.0 and pH 8.0; top row, last two (e and f) show a sodium sensor in visible light and UV light; bottom row, last two (g and h) show another type of pH sensor under visible light and at pH 8.0 under UV light. Source: MIT Media Lab.

tem to identify microbial infections. It is specifically designed to detect urinary tract infections but it can be made to work with other types of infection.

It uses a process called smaRT-LAMP or real-time loop-mediated isothermal amplification to identify bacteria on specially prepared plates.

These fluoresce if specific bacteria are present and the amount of fluorescence can also be used to determine the concentration of the bacteria. Up to 36 samples can be tested at a time (Fig.11).

Apart from the phone, the hardware required costs around US$100. The app is limited to the Samsung Galaxy S7 phone due to camera calibration requirements.

Bio tattoos

Biosensor tattoos have been developed at MIT and Harvard, under the project name "DermalAbyss" or d-abyss. These use the skin itself as an interface to measure parameters such as glucose, pH and sodium levels in the blood.

The skin is injected with a biosensor marker which changes colour according to changes in the parameter being measured. The colour change can be accurately measured with the camera of a smartphone.

The concept has been tested on pig skin samples in the laboratory; there are currently no plans to bring the project forward to a clinical trial or a product for human use (Figs.12 & 13).

Next month:

When we started researching this field, we never imagined there were so many apps out there (much more than we could fit in one issue!).

So next month, we will conclude this feature with smartphone apps that use additional hardware for diagnosis. SC

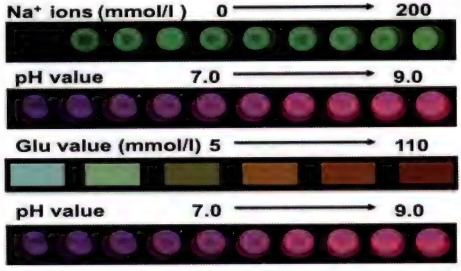


Fig.13: some sample colour changes from biosensor tattoos. The specific colours and thus the values being measured can be determined with a smartphone camera and appropriate software.

The Qualcomm Tricorder X-Prize

Similar to other X-Prizes you may have heard of, the Qualcomm Tricorder X-Prize was intended to promote the development of a hand-held medical device, much like the fictional Tricorder from Star Trek. The winning device was to be able to "diagnose and interpret a defined set of 13 health conditions to various degrees, while continuously monitoring five vital health metrics".

(We discussed the Google Lunar X-Prize on page 8 of the November 2018 issue, which was established to encourage private space companies to build a moon lander).

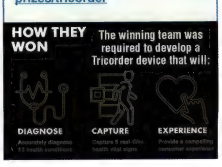
No team met all the requirements of the full prize in the required time, but in 2017, the top prize of US$2.6 million was won by the family-lead team Final Frontier Medical Devices and the second prize of US$1 million was won by Dynamical Biomarkers Group.

Both devices are mentioned in the second article in this series.

DxtER was described as an "artificial intelligence-based engine that learns to diagnose medical conditions by integrating learnings from clinical emergency medicine with data analysis from actual patients. DxtER includes a group of non-invasive sensors that are designed to collect data about vital signs, body chemistry and biological functions. This information is then synthesized in the device's diagnostic engine to make a quick and accurate assessment".

Dynamical Biomarkers' device paired "diagnostic algorithms with analytical methodology in a user-friendly device" and was controlled using a smartphone.

For more details, see: **https://tricorder.xprize.org/prizes/tricorder**



Smooth . . . Our Ne

With Touch and/or Remote Control

Our new dimmer works with most modern lighting, including dimmable LEDs, dimmable fluorescents and dimmable halogen downlights, as well as the now old-fashioned incandescents. It also has a really easy-to-use touch control and even infrared remote control, for ultimate convenience! It's ultra-modern, easy to build and simple to wire up.

By John Clarke

Sleek looks, smooth dimming over a wide range, touch control and infrared remote control are just some of the outstanding features of this new Touch and Infrared Trailing Edge Light Dimmer from SILICON CHIP.

It is ideal for dimming modern LED lamps and it does not have a "last century" style adjustment knob. You don't control your phone or tablet with a knob, do you? You use the touchscreen.

So don't you also want a touch interface for your lighting?

And so that you don't even have to get up from your chair and walk across the room, you can also use a stylish slimline infrared remote control to control the lights. It even provides presets to quickly set the mood that you want!

Virtually all lighting in new or renovated homes is now LED-based, which often means that these homes lack dimmers. If the lamps are dimmable (or can be easily replaced with dimmable versions), then a dimmer like this one is great to retrofit since there are times when you don't want full brightness.

Like when you have just woken up in the morning!

But if you have a modern home, you will want a modern dimmer, so this one is a great choice.

Visually, its minimalistic style with a brushed aluminium plate means it will blend into a modern home – although it looks great in a more traditional setting too.

And the infrared remote control option seals the deal. You can keep it on your bedside table, dining table, lounge. . . wherever you spend a lot of time.

Watching a movie? Don't get up from the couch; you can dim the lights just like in a cinema. The baby needs changing during the night? There's no need to use bright light which can disturb sleep patterns. Just slept in? Ease yourself into the day by slowly ramping up the bedroom lighting.

It's unobtrusive too, because the only part of the dimmer that you see is the wall plate.

We use a commercially available Clipsal Classic 2000 blank plate, so it looks very professional and contemporary. A small lens is added to allow for reception of the infrared transmission from the handheld remote control unit. Extra wall plates can be added in other locations if needed, too.

The infrared handheld controller is not one you have to build yourself. Instead, it is a small low cost, commercially available unit and it looks attractive and professional.

v Universal Dimmer

Features:

- Trailing edge control – suits LEDs
- Slimline appearance
- Touchplate dimming – no knob
- Optional infrared remote control
- Soft on/off (rapidly ramps brightness up or down)
- Supports multiple touch plates
- Wide dimming range
- Low electromagnetic interference (EMI)
- Can operate without a Neutral connection

Hopefully, we've sold you on the idea of this Dimmer. So read on to find out what it can do and how it works.

Requirements for dimming LED lights

You need a universal or trailing-edge dimmer for dimming LEDs or compact fluorescent lights (see panel on trailing edge dimmers). But you also need to make sure that your lights are designed to be dimmable. If they are, it will say so on the packaging and it will probably also be printed on the lamps themselves.

Many LED and fluorescent lights are not dimmable. And we've found that even some that claim they are dimmable don't always "play nice" with certain dimmers!

So it pays to test the lights with the dimmer you intend using before installing either.

Our Dimmer was tested with a few different dimmable LEDs and we found that it worked fine (as it should) but there may be some LED lights out there which will not work when driven from it, so you need to test them yourself.

The same goes for halogens with electronic transformers.

The underside of our new Touch/ Remote Control Dimmer. It mounts on a standard Clipsal plate, which in turn accepts a standard aluminium dress panel.

Some are explicitly labelled as dimmable and most of them will work with this Dimmer. Halogens powered via traditional iron-cored transformers are also dimmable. If you are running several halogen or incandescent lights with this Dimmer, be careful not to exceed its 250W maximum load rating.

Dimming control

The lamp(s) connected to the Dimmer can be controlled in two ways, using the touch plate or via infrared remote control.

With the touch plate, dimming is initiated by simply holding your hand on the touch plate. The light brightness will smoothly decrease or increase. Momentarily lifting your hand and then re-applying it to the touch plate will switch between decreasing or increasing brightness.

It takes three seconds for the light to go from fully off to fully on or vice versa. Dimming stops when either minimum brightness or full brightness is reached.

Want instant light? A quick tap of the touch plate will switch the light on and another quick tap will turn it off. When switching on, the lamp immediately goes to full brightness over a brief period of around 0.4s (400ms). This produces a smooth on/off effect rather than an abrupt change in light level.

Note that a quick tap is any touch that measures between 140ms and 600ms.

Taps shorter than 140ms are ignored (to prevent spurious light switching due to electrical noise etc) while

Specifications

Operating mains voltage range:	200-255VAC
Mains frequency:	50Hz or 60Hz
Minimum load:	8W
Maximum load:	250W
Minimum brightness:	0% (entirely off)
Maximum brightness:	100% when a Neutral connection is available; adjustable when it is not, up to about 95%
Brightness steps:	2% (50 steps from off to full brightness)
Touch dimming time:	three seconds from fully on to fully off or vice versa
Touch control commands:	switch on/off, brighter/dimmer
Infrared remote control commands:	switch on/off, increase/decrease brightness fast (2s) or slow (9s), plus three presets
Dimming steps:	50 for touch control, 100/450 for infrared (fast/slow dimming)
Soft on/off time:	400ms
Quiescent power:	around 1W
Touch control timing:	Touched for <140ms: no action
	Touched for 140-600ms: on/off alternate action
	Touched for >600ms: begins dimming up or down; hold down to continue (alternate action)

presses longer than 600ms initiate the dimming up/down function.

Infrared remote control

While the touch plate has effectively only one control that has to perform several functions, the handheld remote control unit has nine buttons, as shown below.

All of these buttons control the Dimmer in some way.

The "Operate" or on/off button at the top switches the lights entirely on or off, just like a quick tap of the touch plate.

The circle button in the middle of the directional arrows also switches the light on or off, however, it works slightly differently.

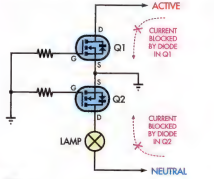
When you press it to switch the light on, it will return to the same brightness level the lamp had before it was last switched off.

Holding the up and down arrow buttons provide a slow increase or decrease in brightness respectively, with nine seconds required to go from fully off to fully on or vice versa. The left and right arrow buttons also decrease or increase the brightness but do so faster, taking only two seconds from one extreme to the other.

The A, B and C buttons provide for three different fixed brightness levels. These are dim, medium and bright lamp settings respectively. As with the on/off control, rather than jumping instantly to the new brightness level, the unit quickly ramps the brightness up or down as required, providing a smooth transition.

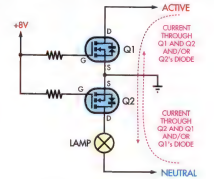
When the Dimmer is initially powered up, the lamp remains off. The

The nine-button remote control we used for this project. There are no doubt many others available which will do the job, but ours came from Little Bird Electronics (www.littlebird.com.au) for the princely sum of $5.87.



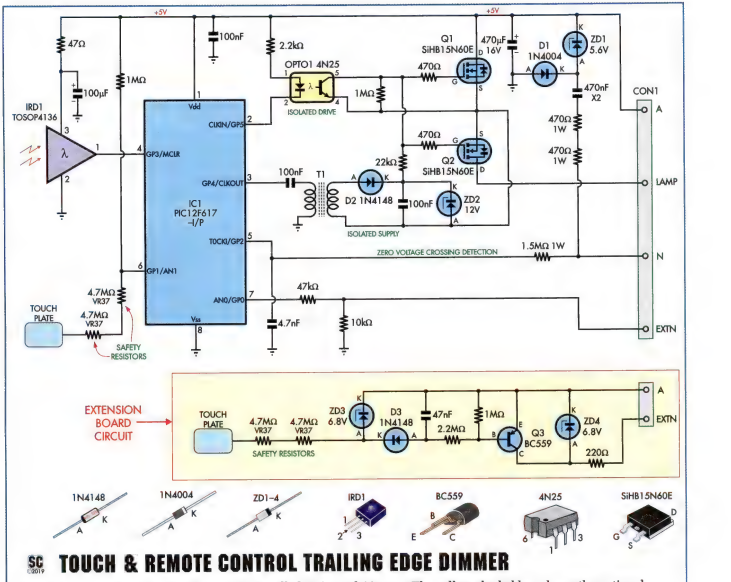
MOSFETS OFF

Fig.1(a): when Mosfets Q1 & Q2 are switched off, current cannot flow through the lamp regardless of the polarity of the Active voltage because one of the two Mosfet body diodes will always be reverse-biased and block current flow. If a single Mosfet was used, it would always conduct at least half the time, severely limiting the possible dimming range



MOSFETS ON

Fig.1(b): when the gates of Mosfets Q1 & Q2 are pulled at least 8V above their source terminals (shown here connected to circuit ground), both Mosfets conduct and so current can flow through the lamp regardless of the Active voltage or the point in the mains cycle. The forward-biased body diode may conduct some current depending on the voltage across the Mosfets.



TOUCH & REMOTE CONTROL TRAILING EDGE DIMMER

Fig.2: the circuit of the Touch and Remote Controlled Universal Dimmer. The yellow shaded box shows the optional extension circuit, only required if you need two or more touch plates for control. Micro IC1 does most of the work, controlling Mosfets Q1 and Q2 via optocoupler OPTO1 and an isolated power supply based on transformer T1. It monitors the mains phase at pin 5 and times the switching of the two Mosfets to achieve the desired lamp brightness level.

standby power drawn by the Dimmer circuit from the mains is just over 1W.

What if there is no Neutral wire?

In most domestic installations, the mains Neutral wire is not brought to the light switch. The Neutral connection to the lamp is usually made in the ceiling; only the lamp Active wire and Active supply wire need to be run through the wall cavity to the switch or dimmer (it saves cable!).

That presents a problem for powering the dimmer circuit. When the lamp is switched on at full brightness, in theory, there is no potential difference between those two wires and so there is no power available to run the Dimmer itself.

But we need it to work in this situation since it is so common.

The solution is to limit the maximum lamp brightness to be just a little bit less than that achieved when it receives the full 230VAC. Since dimming is done by switching the mains off before the end of each cycle, that leaves a small window where mains voltage is still present but the lamp is off. It is during that time that the dimmer draws the power it needs to operate from the mains.

If there is a Neutral connection available, then the dimmer is powered regardless of whether the lamp is on all the time, so maximum brightness will be available.

Our Dimmer caters for both wiring possibilities. When the Neutral wire is not available, you can set the maximum brightness of the lamp, so there is enough mains voltage to power the dimmer without the lamp flickering.

We will describe how this is done in the constructional article next month.

LED light snap-on effect

Many mains-powered LED lamps will "snap on" as the dimming control is increased from off to a low brightness level. This means that the lamp brightness may not rise slowly as expected; instead, the lamp remains off entirely and then springs into life suddenly when you reach a specific brightness setting, with a higher

brightness than you would expect.

This is due to the LED driver requiring a certain amount of voltage and current to start up. Once it has started, you can usually drop the brightness back down to a lower level and the light will remain on.

In other words, you can't get the lamp to light up dimly when increasing its brightness from the off-state. You instead need to switch it on at an intermediate brightness and then reduce its brightness to get it to dim correctly. This effect is more noticeable when you are running the Dimmer without a separate Neutral connection.

Circuit description

The circuit of the Universal Dimmer is shown in Fig.2. Despite providing many useful features, the circuit is quite simple because most of the work is done in the software running on the PIC12F617 microcontroller (IC1).

Mosfets Q1 and Q2 switch mains voltage to the lamp(s), to control their brightness. The way that these control the lamp load is shown in Fig.1. This configuration allows us to control power over the entire mains waveform, switching mains power at the lamp on or off at any time.

The reason that two Mosfets are required for this job is that a power Mosfet contains an intrinsic (or body or "parasitic") diode which cannot be removed; it is inherent to the structure of a Mosfet.

Since the current flow reverses for half of the mains waveform, if we used a single Mosfet, its body diode would conduct half the time and apply the full voltage to the load, whether the Mosfet was switched on or not.

By connecting the two Mosfets in series, with the body diodes in opposite directions and the Mosfets switched off, current flow is blocked in both directions, as shown in Fig.1(a).

When the Mosfets are switched on by pulling their gate voltages high, as in Fig.1(b), current can flow in either direction via the Mosfet channels, mostly bypassing the body diodes.

The body diodes will only conduct if the current through the channel high enough to create a voltage difference across the Mosfet (due to channel resistance) that's higher than the body diode forward voltage.

Driving the Mosfet gates

Mosfets Q1 & Q2 switch on when their gate voltages are higher than the common source terminal voltage. For these particular Mosfets, the difference needs to be at least 8V for conduction with minimal losses.

But the gate voltage can't be too high as any more than 30V could damage the Mosfets. That makes it a bit tricky to provide just the right voltage to keep them switched on when necessary.

The easiest solution is to galvanically isolate the gate voltage source from the rest of the circuit. This is mainly since the +5V rail is connected directly to mains Active, which is necessary for the touch control to work.

The problem is that even if we could generate the required 8-30V supply and then apply this to the Mosfet gates, with their source terminals connected to circuit ground, as soon as Q1 switched on, it would connect Active (+5V) to ground, effectively shorting out the 5V supply and thus shutting the whole circuit down.

By "floating" the gate supply, we eliminate this problem;

Leading vs trailing edge dimming

Our mains electricity supply (nominally 230VAC) is a 50Hz sinewave. To provide a dimming function, this is normally "chopped" in some manner by a switching device which interrupts the mains supply to the lamp, to reduce its brightness. The more of the time this switching device is on, the brighter the lamp.

The most common method of chopping the mains waveform is "phase control", where power is applied continuously for some portion of each half of the mains cycle. Each half of the mains cycle lasts for 10ms and for the entire period, the Active conductor voltage is either higher or lower than the Neutral voltage.

Between each half-wave, there is a "zero crossing" where the Active and Neutral voltages are equal. Each full mains waveform (taking 20ms) is considered to have a phase from 0-360°, with the two zero crossings having phase angles of 0° and 180° and the voltage peaks being at 90° and 270°; see Fig.3.

The terms "leading-edge dimming" and "trailing-edge dimming" refer to the fact that there are two main ways to provide phase control. They work similarly but are generally used in different circumstances.

If you delay applying the mains waveform to the load until a particular phase angle – say, 45° – then allow it to continue to be applied until the start of the next half-cycle, you have reduced the RMS voltage at the load and therefore reduced the power the load draws. This is known as leading edge dimming since you are delaying the leading edge of the mains waveform "seen" by the load; see Fig.4.

Alternatively, if you apply power to the load from the start of the waveform (ie, at 0°) and then cut it before the end of the cycle – say, at 315° – then you are moving the trailing edge of the mains waveform as seen by the load and that is known as trailing edge dimming; see Fig.5.

In both of these examples, the RMS voltage applied to the load is the same – around 219V RMS in a nominally 230VAC system.

The leading edge dimmer has been used for around 50 years, mainly for dimming incandescent lamps. That is because it can be implemented using a simple circuit based on a Triac, as shown in Fig.6.

The Triac is a four-layer semiconductor device which switches on when its gate is driven. But it can't be switched off via the gate; instead, it switches itself off when the current flow through it drops to near zero.

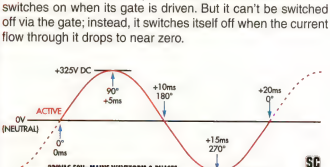


Fig.3: the Australian mains voltage is roughly sinusoidal and repeats at 50Hz (ie, every 20ms). The negative-to-positive transition of the Active voltage is considered the start of each cycle and has a phase angle of 0°. The other zero crossing is at 180° and the two peaks are at 90° and 270°. During phase control, the power to the load is switched at a consistent point in the cycle.

In practice, when driving a resistive load like an incandescent lamp, the Triac switches off when the mains voltage is near 0V. Hence, it's simple to provide leading edge phase control.

Dimming LEDs

Leading edge dimmers are not suitable for use with LED lamps or halogen lamps with electronic transformers. That's because in both cases, the control circuitry rectifies the mains and then filters it with a capacitor. It is the charge on that capacitor which then runs the remaining circuitry, including the lamp.

If a voltage is suddenly applied to this type of circuit, the diodes in the rectifier immediately conduct and draw a high current to charge the capacitor quickly.

Such a high inrush current is manageable if it only occurs infrequently, such as when a light is switched on, but if it's happening every mains cycle (when the Triac in the dimmer switches on), it could lead to overheating and failure.

And even if the dimmer and lamp can tolerate this situation, you would still expect to see ringing, voltage excursions, excessive electromagnetic interference (EMI) and lamp flashing rather than dimming. So clearly it is not workable.

The solution is to use a trailing-edge dimmer instead. The switching device now turns on at the mains zero crossing where there is no potential difference between Active and Neutral. The lamp voltage then rises relatively slowly and the rectifier diodes conduct once the mains voltage exceeds the capacitor voltage. Current is drawn from the mains in much smaller and more tolerable pulses.

Since LEDs are now basically taking over the lighting market, leading-edge dimmers are giving way to trailing edge or universal dimmers (which can operate in either mode).

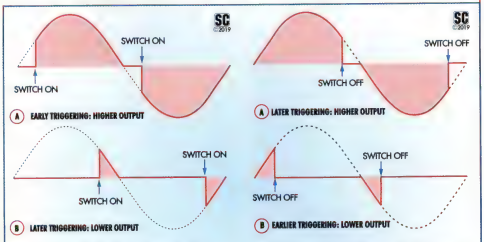


Fig.4: a leading edge dimmer varies the switch-on point during the mains cycle but always switches off at the zero crossing. So the earlier it switches on, the more power is applied to the load and the brighter the resulting light is. But this does not work well with LEDs or with other lamps that have electronic drivers.

Fig.5: a trailing edge dimmer achieves a similar result but it instead switches the lamp on at the zero crossing and then switches it off at some point later in the mains cycle. The later the switch-off, the brighter the lamp. This scheme is compatible with lamps that have electronic drivers, including most dimmable LEDs.

Trailing edge dimmers need to use a switching device other than a Triac; one that can be switched off with gate control at any part of the mains waveform. Fig.7 shows a simplified circuit of a typical trailing edge dimmer. The switching device is normally one or two Mosfets or IGBTs (insulated gate bipolar transistors).

In the circuit presented here, we are using two Mosfets, connected source-to-source. Refer to the circuit description for details on why we've used that configuration. It allows us to switch mains power to the lamp load on or off at any points in the mains cycle.

For more information on leading and trailing edge dimmers and their use with LED lamps, see the article titled "LED downlights and dimmers" in the July 2017 issue of SILICON CHIP (www.siliconchip.com.au/Article/10712).

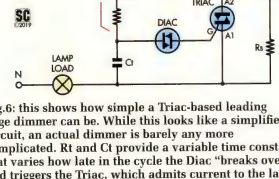


Fig.6: this shows how simple a Triac-based leading edge dimmer can be. While this looks like a simplified circuit, an actual dimmer is barely any more complicated. Rt and Ct provide a variable time constant that varies how late in the cycle the Diac "breaks over" and triggers the Triac, which admits current to the lamp. It automatically switches off at the next zero crossing. Cs and Rs form a snubber to reduce EMI, and Ls helps with EMI reduction too.

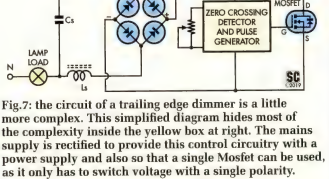


Fig.7: the circuit of a trailing edge dimmer is a little more complex. This simplified diagram hides most of the complexity inside the yellow box at right. The mains supply is rectified to provide this control circuitry with a power supply and also so that a single Mosfet can be used, as it only has to switch voltage with a single polarity. A capacitor is required (not shown) to maintain power supply for the control circuitry while the Mosfet is on.

The dimmer is constructed using two PCBs which "sandwich" one on another. The assembly is mounted onto a Clipsal plate with a touch plate on the opposite side.

the Mosfet source terminals no longer need to be connected for circuit ground to allow us to control the Mosfet gate voltage.

Transformer T1 both provides this isolation and also steps up the 5V control voltage to give a gate voltage above 8V. This transformer comprises a high-frequency toroidal ferrite core with two copper windings. The primary winding is driven by a 2MHz square wave generated at IC1's clock output (pin 3), via a 100nF AC-coupling capacitor.

The secondary winding has four times as many turns as the primary and is isolated from it. The secondary AC waveform is half-wave rectified by diode D2 and filtered with a 100nF capacitor. The result is a nominal 10VDC with the negative side connected to the source of Q1 and Q2, and the positive side to the gates via a 22kΩ resistor and two 470Ω resistors.

The gate voltage is controlled using optocoupler OPTO1. It's necessary to maintain the isolation between IC1, with its 5V rail connected to Active, and Mosfets Q1 and Q2. When IC1's GP5 output (pin 2) goes high, OPTO1's internal infrared LED is off. When this pin goes low, around 2mA flows through that LED, limited by the 2.2kΩ resistor from the 5V supply.

When this LED lights up, it shines on OPTO1's internal phototransistor, shorting out the 10V gate supply to Mosfets Q1 and Q2, switching them off. When the phototransistor switches off, the 10V supply can again pull the Mosfet gates high and so they switch back on.

The Mosfet gates are isolated from each other with 470Ω resistors to prevent oscillation at switch on. A 1MΩ resistor between the collector and emitter of OPTO1's output transistor ensures that Q1 and Q2 remain off when IC1 is not powered.

Mains zero crossing detection

To time the switching of Q1 and Q2 correctly, to get the desired dimming level, IC1 has a timer which is synchronised with the mains zero crossing, ie, the time when the Active and Neutral voltages are equal (which happens 100 times per second with our 50Hz mains sinewave). It therefore needs a way to detect this condition, to synchronise its timer.

This is detected at pin 5 of IC1, via a 1.5MΩ resistor connected to the Neutral conductor (which may be via the lamp(s), in cases where a separate Neutral wire is not available). Detection of the zero crossing is only made at the negative transition, with the positive transition timing being timed as 10ms later.

The 1.5MΩ current-limiting resistor forms an RC low-pass filter in conjunction with the 4.7nF capacitor, which is necessary to reduce the effects of electricity authority control tones which may be superimposed on the 50Hz mains.

These would otherwise cause a noticeable flickering in the lamp due to modulated zero voltage detection.

This does, however, delay the detection of the zero crossing. IC1 compensates for this known delay to determine the actual zero crossing timing.

Note that only one of the two zero crossings is actually detected. The other is calculated from it based on the expected delay from either a 50Hz or 60Hz mains frequency. This improves the stability of the dimmer, especially when operating without a Neutral wire.

Also, the software only checks the state of pin 5 around the expected time of the zero crossing.

If zero voltage detection was active for the entire cycle, switching the lamp on and off would cause false detection due to the change in voltage at the zero voltage input when the lamp is switched. This is important when zero crossing detection is via the lamp rather than directly from the Neutral.

Power supply

As you may have gathered from the explanation above, the power supply configuration for this circuit is intimately related to its operation.

That's because it runs from the same mains supply which it is also monitoring (for zero crossing events) and switching. And in the case where you don't have a Neutral wire connected to the device, it becomes quite tricky indeed.

Besides the isolated Mosfet gate driver section described above, the rest of the circuit "floats" with the nominally 230VAC mains Active waveform. In fact, the Active wire is tied directly to its +5V rail. So you can think of it as if the circuit's supply current is drawn from the Neutral connection; in practice, it flows between Active and Neutral, with the current reversing 100 times per second.

This current flows to/from the Neutral wire through two 470Ω 1W series-connected resistors and a 470nF mains-rated capacitor.

When the Active voltage is below the Neutral voltage, the 470nF capaci-

Here's the extension touch plate control which is similar to the main PCB and mounts in the same way (see below) . . .

tor charges via the two 470Ω resistors and ZD1, which is forward-biased and acts like a standard diode.

When the Active voltage subsequently goes above the Neutral voltage, the 470nF capacitor discharges through diode D1, charging up the 470µF electrolytic capacitor which then powers the rest of the circuit.

Once the charge on the 470µF capacitor reaches 5V, any extra current drawn by the circuit is shunted by ZD1, to prevent the supply voltage rising any further. It limits the supply to 5V, not 5.6V, due to the 0.6V forward voltage of diode D1 when it is in conduction.

When ZD1 conducts, it is the im-

. . . and here's the extension mounted on the Clipsal plate.

Parts list – Trailing Edge Dimmer

1 double-sided PCB coded 10111191, 66 x 104mm
1 PCB coded 10111193, 58.5 x 104mm
1 Clipsal CLOPTO1031VXBA C2000-series standard blank plate with blank aluminium cover
1 CLI449AWE mounting block (optional; see construction article text next month)
1 fresnel lens for IR sensor (Murata IML0688) [RS components Cat 124-5980]
1 infrared remote control [Little Bird Electronics SF-COM-14865]
1 CR2025 3V cell, to suit IR remote control
1 DIL-8 IC socket (IC1)
1 4-way terminal strip, 25A 300VAC with 9.5mm pitch (CON1) [Jaycar HM-3162]
1 18 x 10 x 6mm toroidal core, L8 material (T1) [Jaycar LO1230]
1 1.26m length of 0.25mm diameter enamelled copper wire (T1)
3 100mm Nylon cable ties
1 25mm length of 16mm heatshrink tubing
4 M3 x 6mm panhead machine screws
8 M3 hex nuts
1 15mm length of 0.71mm diameter tinned copper wire

Semiconductors
1 PIC12F617-I/P microcontroller programmed with 1011119A.HEX (IC1)
1 4N25 optocoupler (OPTO1)
1 TSOP4136 infrared receiver (IRD1)
2 SIHB15N60E N-channel Mosfets, 15A 600V (Q1,Q2)
1 1N4004 1A 400V diode (D1)
1 1N4148 small signal diode (D2)
1 5.6V 1W zener diode (ZD1)
1 12V 1W zener diode (ZD2)

Capacitors
1 470µF 16V PC electrolytic
1 100µF 16V PC electrolytic
1 470nF 275VAC X2-class, 22.5mm pitch
3 100nF 63/100V MKT polyester
1 4.7nF 63/100V MKT polyester

Resistors (0.25W, 1% unless otherwise stated)
2 4.7MΩ Vishay VR37 3.5kV safety resistors [RS Components 484-4400]
1 1.5MΩ 1W 5% 2 1MΩ 1 47kΩ 1 22kΩ 1 10kΩ
1 2.2kΩ 2 470Ω 1W 5% 2 470Ω 1 47Ω

Additional parts for each extra touch plate
1 double-sided PCB coded 10111192, 58.5 x 104mm
1 PCB coded 10111193, 58.5 x 104mm
1 Clipsal CLOPTO1031VXBA C2000-series standard blank plate with blank aluminium cover
1 CLI449AWE mounting block (optional; see text)
1 4-way terminal strip, 25A 300VAC with 9.5mm pitch (CON1) [Jaycar HM-3162]
4 M3 x 6mm panhead machine screws
8 M3 hex nuts
1 15mm length of 0.71mm diameter tinned copper wire

Semiconductors
1 BC559 PNP transistor (Q3)
1 1N4148 small signal diode (D3)
2 6.8V 1W zener diodes (ZD3,ZD4)

Capacitors
1 47nF MKT polyester

Resistors (0.25W, 1% unless otherwise stated)
2 4.7MΩ Vishay VR37 3.5kV safety resistors [RS Components 484-4400]
1 2.2MΩ 1 1MΩ 1 220Ω

Additional parts for external switch control
1 Clipsal 30MBPR momentary press switch and matching architrave or standard single-gang switch plate

Infrared remote control using the Pulse Distance Protocol (PDP)

Most infrared controllers use a modulation frequency of 36-40kHz, typically 38kHz, where the infrared LED is switched on and off at this frequency. This is done in bursts (pulses), with the length of and space between the bursts (pauses) indicating which button was pressed.

The series of bursts and pauses is usually in a particular format (or protocol) and there are several different protocols commonly used. This includes the Manchester-encoded RC5 and RC6 protocols originated by Philips. There is also the Pulse Width Protocol used by Sony. The handheld remote used in this project uses Pulse Distance Protocol, originating from NEC.

If you are interested in details on all these protocols and others, see the application note AN3053 by Freescale Semiconductors (formerly Motorola) at: http://cache.freescale.com/files/microcontrollers/doc/app_note/AN3053.pdf

The adjacent diagram (Fig.8) shows the details of this protocol. This is broken up into four panels.

The top panel shows how binary bits zero and one are transmitted. They both start with a 560µs burst modulated at 38kHz. A logic 1 is followed by a 1690µs pause while a logic 0 has a shorter 560µs pause.

The second panel shows the structure of a single transmission. It starts with a 9ms burst and a 4.5ms pause. This is then followed by eight address bits, another eight bits which are the "one's complement" of those same eight address bits (the 0s become 1s and the 1s become 0s). The address bits identify the equipment being controlled by the remote (TV, DVD, radio etc).

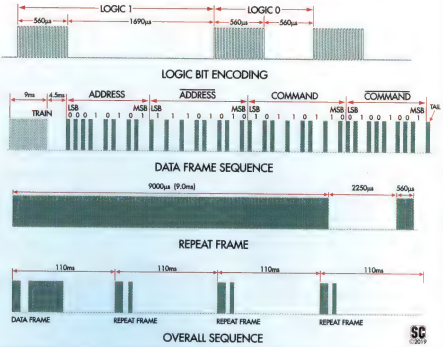


Fig.8: timing details of the PDP infrared remote control protocol. The first panel shows the timing of logic 0s and 1s (consisting of 38kHz bursts of IR energy). The second panel shows how these data bits are combined with the start frame and tail burst to encode a remote control button press. The third panel shows the repeat signal transmitted when a button is held down and the fourth panel shows the series of commands which result from pressing and then holding a button.

These are followed by eight command bits, plus their one's complement, indicating which function should be activated, then finally a 560µs "tail" burst to end the transmission.

Note that the address and command data is sent with the least significant bit first.

The complementary address and command bytes are sent as a way of detecting errors. If the complement data value received is not the complement of the data received then one or the other has been incorrectly detected and decoded.

A lack of complementary data suggests that the received data is not in the PDP protocol and so the signal is being sent by a different handheld remote.

After a button is pressed, if it continues to be held down, it will produce repeat frames. These consist of a 9ms burst, a 2.25ms pause and a 560µs burst. This is repeated at 110ms intervals.

The repeat frame is used to inform the receiver to possibly repeat that particular function, depending on what it is.

For example, "volume up" or "skip forward" actions may be repeated but "mute" may not.

pedance of the two 470Ω resistors and the 470nF capacitor which prevents excessive current from being drawn from the mains.

The 470Ω resistors also limit the in-rush current each time the light switch is turned on, as the instantaneous applied voltage could be as high as 350V DC (the typical Active-Neutral voltage with a 230V mains supply is $325V_{PK}$ but in some areas with abnormally high mains, this could be significantly higher).

If there is no Neutral connection available in the location where the Dimmer is installed, the Neutral connection is made via the lamp load.

In this case, power is only available to the circuit when the lamp is switched off. When the lamp is on, the voltage across Q1 and Q2 is less than 1V and this is insufficient to develop the 5V power supply voltage.

Thus, the phase control range needs to be limited to less than the full mains cycle when there is no separate Neutral wire.

That way, the lamp is not lit for the entire cycle, to make sure that there is still enough power available to run the rest of the circuit. This means the maximum lamp brightness is limited without the Neutral connection.

Dimming control

The touch plate is connected to IC1's pin 6 via two high-voltage 4.7MΩ resistors, while the optional extension board (for a second touch plate – or more) is connected to pin 7 via a standard 47kΩ resistor.

It is essential to use the resistors nominated (ie, Vishay VR37 series 4.7MΩ). As well as limiting any current flow to a person touching the touch plate

to below about 36µA, these particular resistors give a good safety margin as they are rated at 2.5kV (AC) each. Two resistors in series increase the voltage rating to 5kV, giving extra safety.

Trust us; you definitely don't want to risk becoming directly connected to the mains Active conductor – it hurts! And that applies to anyone else who will be using the dimmer, not just you.

Usually, the input from the touch plate at pin 6 is held at 5V (ie, mains Active potential) by the 1MΩ pull-up resistor but if the touch plate is touched, the ground capacitance of the person touching it brings the touch plate to ground potential when the Active voltage is trending upwards.

This effectively pulls pin 6 down to supply ground for long enough to IC1 to detect this condition.

The extension input at pin 7 is normally held low by the 10kΩ resistor. It is pulled high to the 5V supply when the extension circuit touch plate is touched. The 47kΩ resistor protects input pin 7 from transients or incorrect connections.

Note that we need to use a separate input for extra touch plates. If we merely extended the pin 6 input to another switch plate, the extra capacitance and pickup from the extra line length would lead to false triggering on that high impedance input.

Infrared remote control

If fitted, infrared receiver module IRD1 receives and demodulates the codes from the handheld infrared remote control. It incorporates an amplifier and automatic gain control plus a 38kHz bandpass filter to accept only remote control signals. It then detects and removes the 38kHz carrier. The resulting signal is applied to the pin 4 input of IC1, ready for code detection.

The handheld IR remote is a small unit measuring only 80 x 40 x 7mm. It is powered by a CR2025 3V button cell. It has nine snap action pushbuttons on its front panel. The buttons include a Power on/off ("operate") button, three buttons labelled A, B and C buttons and a 5-switch array for up, down, left, right and a central accept or OK button.

The 5-button array is commonly used for volume and channel selectors or forward, reverse, left and right functions.

There isn't too much information about the electronics in the handheld remote except that it uses a 16-pin surface-mount remote control IC, designated HB8101P.

Even if your loungeroom, etc has multiple LED lights on one switch, our trailing-edge dimmer will handle them – up to a maximum of 250W. And as most domestic LED lights are in the order of 8-20W each, that's an awful lot of LEDs that you can control.

Each time a button is pressed, it transmits a unique code is by pulsing an infrared (IR) LED. The infrared signal is sent as 38kHz bursts, using what is known as Pulse Distance Protocol (PDP). This protocol is described in the adjacent panel.

IC1 receives this signal and decodes it. If the signal is recognised as a valid code associated with a pushbutton on the IR remote, the required dimming function is activated.

Extension circuit

The circuit of the extension board, required to add a second (or third...) touch plate to control the same set of lights is shown at the bottom of Fig.2. It is pretty simple as it is only a means for the extra touch plate(s) to send a signal to microcontroller IC1 on the main board, which then treats the event identically to a touch of its local plate.

While the extension touch plate is not touched, PNP transistor Q3 is held off via the 1MΩ resistor between its base and emitter. When the touch plate is touched and the Active voltage is above Earth, Q3's base is pulled low via the two safety resistors, diode D3 and the 2.2MΩ resistor.

This switches on Q3 and the EXTN connection is pulled up to the Active potential, which is also the +5V supply for IC1 on the main board. This pulls pin 7 (digital input GP0) of IC1 high, sending it a signal that the plate has been touched.

The 47nF capacitor acts as a filter and prevents sudden electrical transients (eg, lightning or EMI) from switching on Q3. This capacitor also acts to holds Q3 on sufficiently long enough for detection by IC1 on the main dimmers, even with a very quick tap on the plate.

Zener diode ZD3 protects against excessive voltages at the cathode of diode D3 when the plate is being touched, as the potential difference could be hundreds of volts. Current is limited to a very low level by the safety resistors.

Zener diode ZD4 and the 220Ω resistor at the collector of Q3 provides protection if the connections to the main circuit are wired in reverse. In this case, ZD4 will be forward-biased, protecting Q3, while the 220Ω resistor limits the fault current. A thinned section on the PCB will fuse if this connection is made for long. You would then have to repair it after fixing up the wiring.

You also have the option of using a momentary contact mains-rate switch (eg, Clipsal 30MBPR and switch plate) instead of the extension board, as a secondary dimmer control/light switch. This just needs to be wired up to connect the Active and Extension (EXTN) terminals when pressed.

Multiple extension boards can be wired in parallel, between the A and EXTN terminals, if you need more than two dimmer controls.

Coming up next month

In part 2 next month we will have all the construction and wiring details, testing and adjustment steps and some usage tips. SC

Review by Tim Blythman

RIGOL MSO5354
Mixed Signal Oscilloscope

The MSO5000 series is the latest range of mixed-signal oscilloscopes from Rigol. They were released a few months after the high-end MSO7000 series. Emona Instruments lent us a top-of-the-range MSO5354 with all options installed for review. The entry-level scope in this series, the MSO5072, starts at around $1500 and can be upgraded later with more channels or bandwidth as needed.

The MSO5000 series is based around a custom ASIC (application specific integrated circuit), the Phoenix Oscilloscope ASIC chipset, which allows for sampling rates of up to 8GS/s and waveform capture rates of up to 500,000/sec. It also supports enough memory to store one hundred million samples, although this scope can be upgraded to 200Mpoints of memory.

The large sample capacity of up to 200Mpoints is important since it means that more data is available for analysis via methods such as FFT (fast Fourier transform) spectral analysis. It also allows the user to zoom and pan through a long period of captured data, while still retaining fine details of the waveform.

The models in the MSO5000 range vary from two channels with 70MHz bandwidth (MSO5072) all the way up to the four channel model with 350MHz bandwidth (MSO5354) that we're reviewing. Since the MSO5072 can be upgraded to have the same features as the MSO5354, the internal hardware is essentially the same for all models within the series and the upgrades simply allow more features to be used.

While this is useful in that you can choose features according to your available budget and still have the option to upgrade the difference later, we wonder if it will not be long until someone succeeds in upgrading their MSO5072 without purchasing the official upgrade option.

If you're not sure what capabilities you need, you can simply purchase an MSO5072 and then if you run into a situation where it isn't up to the job, upgrade it as needed. So you aren't paying for extra capability at the start that you may or may not need in future.

Additional software options available on all scopes in the MSO5000 series are up to six serial protocol analysers, twin 25MHz arbitrary waveform generators and power analysis software. Our sample unit included all these options, which would otherwise need to be purchased separately or as a bundle.

There is a large socket under the sizeable (9-inch, 1024x600 pixel) display which accepts an IDC header, which is the connection point for the 16-channel digital logic analyser. Utilising these digital inputs requires a separate, optional set of logic analyser cable and probes.

By the way, besides its performance, the large colour display is a good reason to consider purchasing an MSO5000-series scope rather than one of its smaller cousins.

Features & Specifications

- 9-inch LCD touchscreen display with 1024 x 600 pixel resolution
- 2 or 4 analog channels
- 16 digital channels (requires optional Active Logic Probe, not included)
- 2 arbitrary waveform generator outputs (25MHz/200MSa/s)
- Communications interfaces: USB Host (GPIB), USB Device (eg, flash drive), Ethernet, HDM
- Bandwidth: 70MHz, 100MHz, 200MHz or 350MHz*
- Sampling system: 8-bit, 8GSa/s (shared between all channels)
- Sample memory: 100 million points, upgradeable to 200 million points
- Waveform capture rate: 500,000 waveforms per second
- Serial decoders: RS232/UART, I^2C, SPI, CAN, LIN, I^2S, FlexRay, MILSTD-155
- Other analysis modes: Histogram, Math x 4, FFT, Digital Voltmeter, Frequency Counter, Power Analysis

** Depends on model, all upgradeable*

First impressions

The most striking thing about the scope when you first see it is that it has a black case. We didn't mind this in general, except for the fact that the small number of embossed markings on the features below the screen were less legible than they might have been with a white or beige case.

When turning the unit on, it takes about a minute to boot into a usable scope screen, which is much longer than we'd like. There's a progress bar at the bottom of the screen which moves smoothly left-to-right but you still have to wait about 15 seconds after it reaches the right-hand end before you can use the scope.

Once booted, the display is uncluttered, with small on-screen buttons visible above and below the main graticule.

The displays along the top of the screen to the horizontal timebase and trigger levels are actually active parts of a touchscreen, and can be pressed to edit these values directly.

We are seeing more and more scopes with touchscreens, although the ones we use day-to-day in the office do not have touchscreens. It didn't take long to get into the habit of using the on-screen controls, if for no other reason than it is more intuitive than using a rotary encoder to navigate the various menus. And like most newer scopes there are many options available to navigate.

And just like many portable devices, gestures such as pinch, zoom and swipe can be used to scale and shift the traces in the main display. We found this wasn't very snappy, and were comfortable with dialling these in via the conventional rotary encoders.

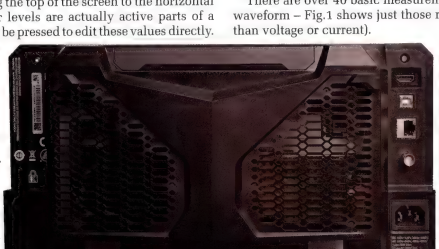
You are not forced to use the touchscreen on this scope as all functions can be activated using the traditional button-and-knob controls if desired. You can even temporarily disable the touchscreen function if you want to – an excellent way to keep finger grease off the LCD!

Having some experience using other scopes, we had no trouble getting a trace on the screen and setting the controls to make it stable. The "Measure" button allowed us to quickly bring up a display showing such characteristics as frequency, period and peak-to-peak voltage.

We noticed a bit more fan noise from the unit during operation than we would expect but it isn't overly loud.

Useful features

There are over 40 basic measurements possible on each waveform – Fig.1 shows just those relating to time (rather than voltage or current).



On the back of the scope are connections for HDMI, USB-B (to connect to a computer), Ethernet and a BNC socket marked 'TRIG OUT', as well as mains power. The TRIG OUT socket can generate a pulse on each trigger event or can signal the results of the pass/fail test.

The best thing about the measurements, though, is that you can select ten different measurements that can all be displayed simultaneously along the bottom of the screen. Compared to the four that many older scopes can show, this is a revelation. You ideally want at least eight measurements with a four-channel scope (eg, frequency and amplitude for each channel) and having two more spare is fantastic.

Another significant aspect of the measure-

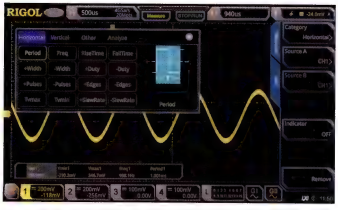


Fig.1: the Measure button gives access to over 40 trace measurements that can be displayed (up to ten at a time) along the bottom of the screen. The Horizontal tab gives access to time-based measurements, while the Vertical tab gives voltage measurements such as peak-to-peak, RMS, average and even overshoot.

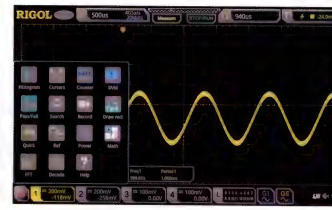


Fig.2: the Function Navigation button in the bottom-left corner opens the menu for more advanced analysis functions and settings including FFT, mathematical calculations, power analysis and digital signal decoding. Power analysis and digital signal decoding require an optional add-on software to be applied to base-level scopes.

ments on this scope is that you can choose whether the scope uses the traces that are visible on-screen to calculate the readings, or it can use its entire memory. For example, if you are using min/max voltage measurements, you may want it to use trace data that is not immediately visible.

On that theme of being able to show a lot of useful stuff on the screen at once, this scope can also display four "math" traces at once (FOUR!). That's way better than the single trace that many other scopes (some very expensive) can show. There are definitely times in the past when we would have loved to have that feature.

This scope has a wide range of triggering options, including Edge, Pulse, Slope, Video, Pattern, Duration, Timeout, Runt, Window, Delay, Setup/Hold, Nth Edge and Serial. Many other scopes do not have options like Runt (used to find occasional short pulses) or Window, which triggers when the trace passes through a rectangle that you can drag on the touchscreen.

Like most other scopes, this one uses an 8-bit analog-to-digital converter (ADC). That does not give quite as good vertical resolution as a scope with a 10-bit ADC. But one of the selling points of Rigol scopes is that their front ends are usually low-noise types, allowing you to still monitor quite low-level signals without them getting "lost in the noise".

While we don't think this scope is quite as good as some of Rigol's other scopes in that respect, it does have a 1mV/div maximum vertical sensitivity which is pretty good, and the noise level still seems quite low, so it should be quite good at probing low-level analog signals.

The noise level is around 1.25mV peak-to-peak/250µV RMS with 20MHz bandwidth limiting, rising to about 2mV peak-to-peak/400µV RMS with the full 350MHz bandwidth – see Fig.8.

Regarding serial decoding and triggering, once again the MSO5000 series is quite generous in allowing you to decode up to four serial buses at once, while optionally triggering off one of them (eg, on a value match). You can see an example of serial decoding in Fig.7.

The optional power analysis software is useful for those working with switchmode power supplies and similar devices. With appropriate probes connected to the right points in the circuit, it can calculate information such as power quality, efficiency, power factor, crest factor and do ripple analysis.

Function Navigation button

The scope has a button in the bottom-left corner of the screen, called the "Function Navigation" button (Fig.2), which gives access to more options from a simple on-screen digital voltmeter through to FFTs (Fig.6) and signal decoding. The list includes a pass/fail tool, which can be used to create tests similar to eye tests.

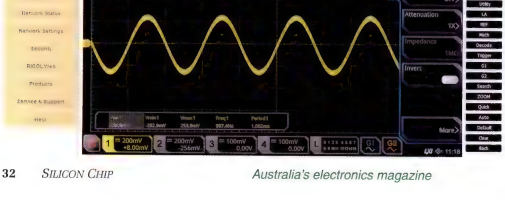


Fig.3: the web interface is easy to access via the scope's IP address from a web browser, and provides control of most of the scope's features as well as showing what's on the screen.

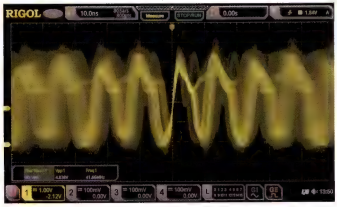


Fig.4: the display persistence setting allows signal jitter to be more clearly seen than on many other scopes. The amount of shift from the trigger point is visible over many cycles. It's also helpful for getting an idea of amplitude modulation/instability, runt pulses and other phenomena.

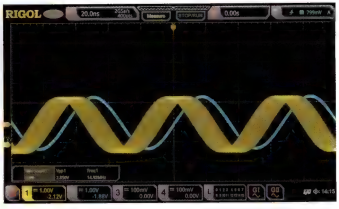


Fig.5: one minor disadvantage of the persistence setting is the tendency to completely obscure other waveforms. In this case, the cyan waveform is almost completely hidden where it overlaps. The traces need to be shifted up or down so they don't overlap if you are to see all their details.

To use this feature, you set up an envelope; the easiest way to do so is to input a 'passing' signal and allow the scope to create the envelope around it. The pass/fail tool can then quickly indicate whether a probed signal is within expected limits or not.

Basic controls

Probe settings are found by simply pressing the corresponding channel button. This lets you select the coupling mode (AC/DC), bandwidth limit (off/20MHz/100MHz/200MHz) and probe attenuation, over a wide range of values from 0.01 times to 50000 times.

While the MSO5354 does not have automatic probe sensing, you only really need to change the attenuation setting when changing probes. If you forget to set the attenuation and capture some data, you can still change it as the display adapts automatically to the new settings.

Connectivity

We were curious about the various connections that are available on the back of the scope. It features HDMI, USB (a type-B socket) and Ethernet connections, as well as a BNC socket marked 'TRIG OUT'.

Typically, screen grabs are made by inserting a USB flash drive into the USB Type-A socket on the front of the unit and saving the screenshot as a file on the flash drive. While this is possible on the MSO5354, the aforementioned sockets make other options available.

We found the easiest way to get our scope grabs was to connect an Ethernet cable. By default, DHCP is enabled and so the scope is automatically allocated an IP address.

After entering the IP address in our browser, we were able not just to view the scope screen and save images, but we could control most of the functions as though we were touching the touchscreen. Many of the hardware buttons are mapped to a column of extra buttons on the web page view of the scope screen (see Fig.3).

Such a setup is great if you have any need to access the scope remotely for any reason, and although a bit slow at times, the browser approach provided access to practically all the scope's functions. It even supports devices like phones and tablets – as long as they are on the same network and have a decent browser, it should work.

It appears the unit can also print to a network printer and

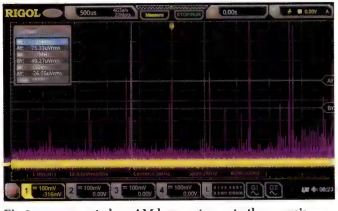


Fig.6: we connected an AM loop antenna to the scope's input and set it up to run an FFT from 500kHz to 2000kHz, covering the AM broadcast band. This display was updating around once per second, and although the peak at 1.25MHz under the cursor did not appear to correspond to a broadcast station on an AM radio, the next one to the left matched well with a strong signal at around 1218kHz.

Fig.7: the serial decoding tool is an optional extra, and can be applied to any of the four analog inputs or the 16 digital inputs if the Logic Analyser add-on is fitted. Here, a 115.2kHz square wave is being correctly decoded as valid 230,400 baud serial data, as bytes of 0x55 hexadecimal.

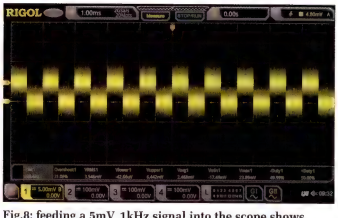


Fig.8: feeding a 5mV, 1kHz signal into the scope shows how it handles low-level signals. Bandwidth limiting was enabled for this test (20MHz). Some of the noise would be from the signal source and/or RF pickup in the probe. Also note the full complement of ten quick measurements along the bottom of the screen.

send emails with the scope's screenshots attached, although we did not have the time to try any of these features.

You can also download and install the dedicated "Ultra Sigma" application to your PC, which can control the scope via USB, Ethernet or GPIB. But the web interface is adequate for many jobs, even if somewhat laggy.

If you need a better display of the scope's screen, the HDMI interface would be ideal. It merely needs to be turned on via the Utility->IO->HDMI menu. The screen resolution used is 1280 x 720, with the 1024 x 600 pixel scope display centred on the monitor.

Persistence

One feature that we found handy is the persistence setting. This allows previous sweeps of the trace to remain on the screen for a while. The traces appear to fade slowly, just as an analog scope raster would. When viewing traces that are unstable or have jitter, the persistence helps to indicate the nature of the instabilities.

Many cheaper scopes have persistence but it's often unusable – a gimmick, essentially. On a scope like this, with a proper ASIC behind it, it's an entirely different proposition.

A less capable scope will tend to render traces as a solid mass of trace colour (more or less). It can be difficult to tell how the jitter is spread, or how the waveform varies from cycle to cycle in other ways, such as amplitude variation, because all traces are pretty much the same intensity.

On the MSO5354, the trace is reinforced in places where it lands consistently, and appears darker when it lands sporadically in other parts of the graticule (see Fig.4).

While this works well with a single trace, when multiple traces overlap, they do not undergo any alpha blending, so that a second trace can be swamped entirely in places by a faint pass of the first trace (see Fig.5).

Since the second trace would be swamped in such cases on other scopes, this is a minor complaint, and you can always separate them if it becomes a major problem. But it would be a nice refinement to incorporate some alpha blending between different traces.

Waveform generator

One of the features we haven't seen before on any scope is the inclusion of a dual arbitrary waveform generator (AWG). We could see how having two separate channels could come in useful. You may want to use one channel to generate a clock signal and another to inject a test signal elsewhere in the circuit, for example.

The AWG in this scope can generate sinewaves up to 25MHz (at 200MSa/s), which is a little bit higher than some other scopes we have used (they topped out at 20MHz). Of course, other waveforms like square and triangle cannot be produced at the full 25MHz as there would be too much rounding. Square waves up to 15MHz are possible.

The AWG has other nice features such as modulation, sweep and signal burst options.

Quick button

There is a button marked "quick" to the right of the display, and by default, it is programmed to save a .png screenshot to an inserted USB flash drive. But it can be programmed for other jobs such as to reset the measurement statistics, start recording, or a number of other actions. We find the default action quite useful as making screen grabs is something we need to do frequently.

On the bench

The unit has a fold-up handle and fold-down feet. The handle is firmly recessed, taking a surprising amount of force to raise. The collapsible feet under the unit allow the scope to be raked back slightly when sitting on a flat surface. It doesn't actually change the angle much, and the feet tend to fold up (suddenly) if the scope is tilted forward, such as if you are plugging something into the rear.

Otherwise, the unit is quite compact, if somewhat heavy for its size. We found the screen pleasant to look at. Although there are settings to adjust trace intensity and graticule brightness, the various other display elements do not appear to be adjustable.

Conclusion

With digital protocols appearing in more projects, we would have like to see the Logic Analyser function and serial decoding included, as adding these to the base MSO5072 scope doubles its price. Having said that, users who are mostly working with analog circuitry may not see the benefits.

While there is the opportunity to start with a lower-end unit and upgrade as needed, the pricing structure does make it better value to purchase the higher bandwidths from the start.

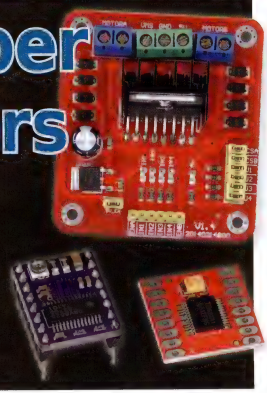
We found the MSO5354 straightforward to use and found that it was able to do anything that we would have asked of it, and would definitely consider it if ever needed to upgrade one of our existing scopes.

We should mention that we ran into a few user interface glitches while testing this scope out, eg, times when the touchscreen would not respond to press but the buttons still worked. But it is a pre-production unit and Emona warned us that it would be a bit buggy. They assured us that production models would not have these problems (and maybe the boot-up time will be faster; surely, one can hope...)

Where from, how much:

Rigol 'scopes are distributed in Australia by Emona Instruments Pty Ltd (www.emona.com.au; tel 1800 632 593). The top-of-the-range Rigol MSO5354 (as reviewed) retails for $6452.60 inc. GST; the entry-level model in the range, the MSO5072 retails for $1479.50 inc. GST SC

Three Stepper Motor Drivers



Want to build your own 3D printer or CNC machine? You will need multiple stepper motors to control it, and a way to drive them. Or maybe you have some stepper motors from old printers or disc drives and want to reuse them. Here are three of the most common stepper motor driver modules and how to use them.

This article assumes you understand the basics of how stepper motors work. If you want an introduction to this type of motor then read our primer in the January 2019 issue (siliconchip.com.au/Article/11370).

The first driver module we're looking at is also the largest, at 60 x 55 x 28mm, including the finned heatsink for the driver IC. It's based on the ST Microelectronics L298N dual H-bridge driver chip and is currently available on eBay for less than A$3.80.

The "N" on the end of the chip version signifies that it's in a 15-pin Multiwatt Power package, intended to be mounted vertically on a heatsink. ST Micro also make a similar version (L298HN) intended to be mounted horizontally, and a version in a PowerSO20 SMD package (L298P).

Fig.1 shows a simplified block diagram of what's inside the L298. It has two full H-bridge drivers (using bipolar power transistors) and so can drive both stator windings of a standard two-phase bipolar hybrid stepper motor.

Each bridge has an enable input and two logic control inputs, and both bridges have their negative supply connections brought out separately, to allow for an external current sensing resistor (RSA and RSB, shown in red).

The L298 can operate from supply voltages from 6-46V and can handle up to 2A per bridge. The inputs are TTL compatible. This makes it the most rugged of the driver ICs we're looking at here, especially when it's fitted to that 23 x 25 x 15mm finned heatsink.

Fig.2 shows the full circuit of the L298N-based driver module. In addition to the L298N chip itself (IC1), there's regulator REG1, which provides a 5V supply for the logic circuitry from the stator supply voltage V_{MS}, if no separate 5V supply is available. REG1 is enabled simply by leaving the jumper shunt in place on the "5V_EN" header.

There are also eight MDDM7 fast-switching silicon diodes to ensure that all four outputs of IC1 are protected from damage due to back-EMF spikes from the motor stator windings, at the end of each current pulse.

The upper diodes prevent the outputs from swinging more positive than one diode forward voltage drop above the supply voltage (V_{MS}), while the lower diodes prevent them from swinging below ground by more than one diode forward drop.

Note that there are no current sensing resistors fitted between the $Sense_A$ (pin 1) and $Sense_B$ (pin 15) pins of IC1 and ground. Instead, these pins are brought out to the two pairs of header pins (CSA and CSB) at the right-hand end of the 6x2 pin DIL header, just below IC1 in Fig.2.

This allows you to connect in current sensing resistors if you wish, or just short both pins to ground (by leaving the jumper shunts in place) if you do not need current monitoring.

The other four pairs of header pins (U1-U4) allow you to disconnect the four 10kΩ pull-up resistors between the control inputs of IC1 and +5V. Four of the five indicator LEDs (LEDs1-4) show when each of the four logic inputs is high, while the fifth (LED5) is a 5V power-on indicator.

This module is quite flexible but it has one significant shortcoming: it is purely a dual H-bridge stepper driver, lacking any built-in indexing controller.

ST Micro make a matching controller chip for use with the L298, called the L297. This can control the L298 for full- or half-stepping, wave microstepping and clockwise or anticlockwise rotation. It can also sense the voltages

Fig.1 (right): block diagram of the L298N IC, which is shown as part of the module above, attached to the heatsink.

across the current sensing resistors CSA and CSB, and use PWM to control and regulate the stator winding currents.

However, the L297 chip costs around $16 – nearly four times the price of the L298 module itself.

Instead of using an L297 controller chip, you can use software running in your Arduino, Micromite or some other micro. Developing this can be a bit of a challenge but it is by no means impossible.

By the way, the L298N module isn't restricted to driving a stepper motor. It can also be used to drive a pair of conventional brushed DC motors – one from each of the two H-bridges.

All you need to do is feed one input of each bridge with a PWM (pulse-width modulated) pulse stream. You could drive one input for clockwise rotation and the other for anticlockwise rotation.

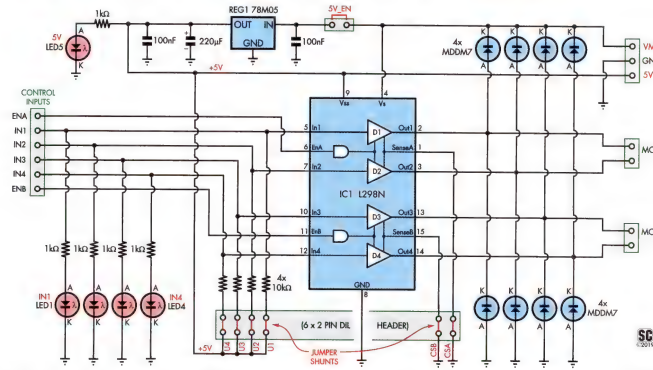


Fig.2: complete circuit diagram of the L298N-based stepper driver module. CSA and CSB can be fitted with two current-sensing resistors if needed, otherwise they can just be shorted to ground.

DRV8825-based module

The next module is much smaller and combines a stepper motor controller and driver, both within the Texas Instruments DRV8825 chip. The module measures just 20 x 15 x 16mm, including the stick-on heatsink; and is currently available from eBay suppliers for around $2 each.

The DRV8825 chip packs a lot into a 28-pin SSOP (SMD) package, as you can see from the internal block diagram, Fig.3.

There are two full H-bridge drivers, labelled MOTOR DRIVER A and MOTOR DRIVER B. These use N-channel power Mosfets and can operate with a supply of 8.2-45V, with a drive capability of up to 2.5A (for each channel) at a supply voltage of 24V.

Each driver has provision for connection of current sensing resistors at the bottom of each bridge (I_{SENA} and I_{SENB}).

The block above the motor drivers is a charge pump used to develop the gate drive supply for the upper Mosfets in each bridge.

Then at upper left, there's a 3.3V regulator, which can provide the current reference voltages for the two bridges (AV_{REF} and BV_{REF}).

The DRV8825 also includes its own stepper control logic/indexer block, shown at lower left. This has STEP and DIR logic inputs for basic motor control, plus three MODE control inputs (MODE0, MODE1, MODE2) which determine the stepping mode.

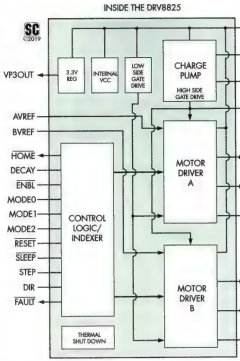


Fig.3: block diagram of the DRV8825 IC.

A total of six different stepping modes are available: Full-stepping, half-stepping, quarter-stepping and three different microstepping resolutions (8/16/32 microsteps per full step).

The microstepping is performed using PWM current control together with synthesised sine and cosine waveforms.

Internal feedback from the I_{SENA} and I_{SENB} pins allows the PWM circuitry to regulate the motor winding currents at the same time. The chip supports fast, slow or mixed current decay modes.

The $\overline{SLEEP}$ input allows the internal circuitry to be shut down for very low current drain between active motor drive periods. There are also $\overline{ENBL}$ and $\overline{RESET}$ inputs, both of which have internal pulldowns. And there's a $\overline{FAULT}$ output, which goes low if the device detects an over-temperature or over-current condition.

Fig.4 shows the full circuit of the DRV8825-based stepper driver module, and there's little in it apart from the DRV8825 chip (IC1).

The 10nF capacitor between pins CP1 (1) and CP2 (2), and the 100nF capacitor connected between the V_{CP} pin (3) and the motor voltage line V_{MA} are needed so that the internal charge pump can develop the high side gate drive voltage for the two internal H-bridge drivers.

The chip's I_{SENA} and I_{SENB} output current sensing pins are connected to ground via 0.1Ω resistors, to allow the regulation circuitry to operate. Trimpot VR1, shown at upper left, allows the maximum current level in each

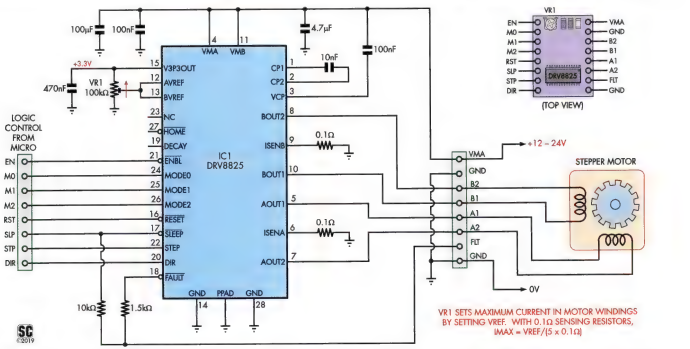
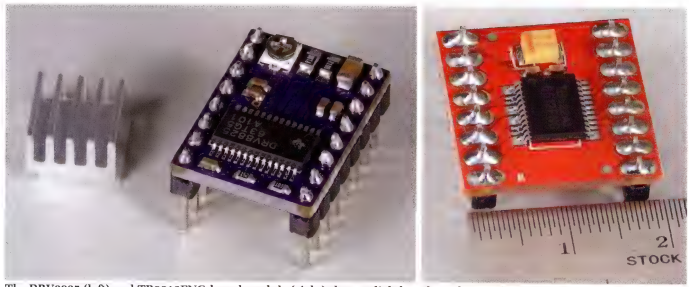


Fig.4: complete circuit diagram of the DRV8825-based stepper driver/controller module. While this circuit is less complex than the L298N-based module shown in Fig.2, it doubles as a controller and driver instead of only being a driver.



The DRV8825 (left) and TB6612FNG-based module (right) shown slightly enlarged. Note the stick-on heatsink for the DRV8825, which would likely be required when driving large stepper motors with windings that pull 1A or more.

motor winding to be set to any desired level, by setting the voltage at the AV_{REF} and BV_{REF} pins.

The DRV8825 data sheet advises that there is an op-amp with a gain of five times in the feedback circuit from the I_{SENA} and I_{SENB} pins, so the relationship between the maximum motor winding current, the sensing resistor values and the V_{REF} voltage (set by VR1) is quite straightforward:

$$I_{MAX} = V_{REF} \div (5 \times R_{SENSE})$$

So with the 0.1Ω sensing resistors used in this module, the maximum winding current (I_{MAX}) will be equal to $V_{REF} \times 2$. As a result, VR1 can easily set the maximum current level up to 2.5A. For example, setting VR1 so that V_{REF} = 1.0V will give a maximum winding current of 2A.

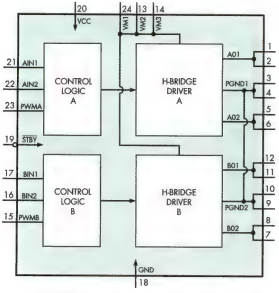
As you can see, despite its tiny size, the DRV8825 has a surprising range of capabilities, including a very flexible built-in indexing controller to simplify controlling a stepper motor from a micro.

TB6612FNG driver module

The third stepper motor driver module is based on the Toshiba TB6612FNG chip. It's slightly larger than the DRV8825-based module, measuring only 20.5 x 20.5 x 11mm, including headers. Currently, it's available from various suppliers on eBay for around $1.65 in one-off quantities.

Fig.5 shows a simplified block diagram of what's inside the TB6612FNG, which comes in a 24-pin SSOP SMD package. It's basically a pair of H-bridge drivers, each driven from a control logic block. So in many ways, it's rather like the L298N, except that the H-bridges use LDMOS power transistors rather than bipolar power transistors.

The TB6612FNG is rated to operate at a maximum motor supply voltage (VM) of 15V, and to deliver output currents of up to 1.2A average or 3.2A peak, for each channel. But it also needs a logic circuit supply voltage (V_{CC}) of between 2.7V and 5.5V, and there is no on-chip regulator to derive this from the motor supply. So this must be supplied externally.



INSIDE THE TB6612FNG MOTOR DRIVER IC

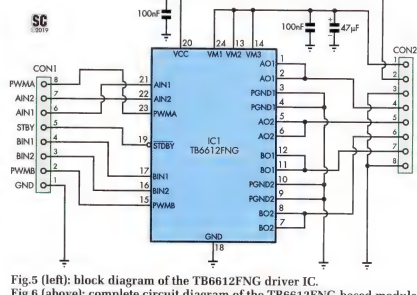


Fig.5 (left): block diagram of the TB6612FNG driver IC.
Fig.6 (above): complete circuit diagram of the TB6612FNG-based module which is only a driver module and does not have any control circuitry.

Note that although the ground connection of each H-bridge is brought out to a pair of device pins (3 & 4, 9 & 10), these pins are all linked together inside the device.

You therefore can't individually monitor or control bridge currents. You'd have to use a single resistor, and it would develop a voltage corresponding to a vector sum of the two bridge currents.

By the way, like the L298N, the TB6612FNG does not include any indexing/control circuitry ahead of the control logic. So it too needs external indexing hardware or software to drive a stepper motor.

On the other hand, it's suitable for driving a pair of brush-type DC motors, using PWM input signals to control motor speed and the A_{IN1}/A_{IN2} and B_{IN1}/B_{IN2} signals to determine rotation.

Fig.6 shows the actual circuit of the TB6612FNG based driver module, and clearly, there is very little in it apart from the main chip itself (IC1).

There are just three bypass capacitors on the supply lines and two 8-pin SIL headers (CON1 and CON2) to make the input and output connections. It couldn't be much simpler.

Trying them out

Since the driving schemes of the L298N and TB6612FNG are quite similar, we've decided to concentrate on demonstrating how to use the L298N and DRV8825-based modules. And we're going to demonstrate driving one from an Arduino and one from a Micromite.

You should not have difficulty adapting our examples to different combinations of the modules and controllers if it turns out that you'd prefer to use some other pairing.

First, let's start by driving the L298N-based module from an Arduino. While this module lacks its own indexing controller, the Arduino IDE comes with a library called "Stepper" which has functions to perform indexing. That makes hooking up controller chips like the L298N (or the TB6612FNG) quite easy.

Fig.7 shows how we connected the L298N module to an Arduino Uno and a typical bipolar stepper motor. The connections between the Uno and the module inputs are the defaults for the Stepper library, so it's important to follow these carefully.

The stepper motor windings are each connected to either the MOTOR A or MOTOR B output terminals, while the V_{MS} and GND terminals are connected to the motor power supply.

All the jumper shunts are left in place on the module.

Also, note that the module's centre GND pin needs to be connected to one of the GND pins of the Arduino. That's because there is no other connection between the two GNDs, and the control signals would otherwise not work correctly.

The Arduino IDE Stepper library comes with some example sketches written by Tom Igoe. We adapted one of these to make it easier for our readers. It's called "SCstepper_oneRevolution.ino", and you can download it from the SILICON CHIP website. It directs the stepper motor to rotate in one direction by a full revolution, then reverse and rotate back by a full revolution.

The number of steps required for a full revolution needs to be added to the sketch before you run it. The correct figure for many motors is 200, so that is the default.

If you find this sketch interesting, you'll find another three sketches in the "Examples" folder of the Stepper library folder on your PC (if you have installed the Arduino IDE). These will all work with the setup shown in Fig.7, performing different functions.

Microstepping with the Micromite

We decided to drive the DRV8825-based module from a Micromite because with its inbuilt indexer, it's a little easier to program "from scratch".

Fig.8 shows how we connected the module between the Micromite and a bipolar stepper. The main STP and DIR inputs of the module are driven from pins 10 and 9 of the Micromite, with the $\overline{SLP}$ and $\overline{RST}$ inputs both driven from pin 16.

Similarly, the $\overline{ENBL}$ input is driven from pin 22, while the M0, M1 and M2 mode control inputs are driven from pins 21, 18 and 17 respectively.

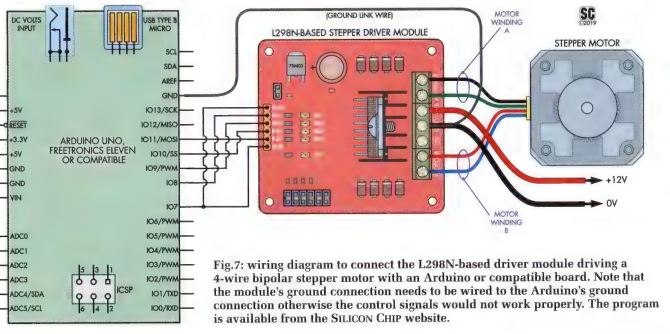


Fig.7: wiring diagram to connect the L298N-based driver module driving a 4-wire bipolar stepper motor with an Arduino or compatible board. Note that the module's ground connection needs to be wired to the Arduino's ground connection otherwise the control signals would not work properly. The program is available from the SILICON CHIP website.

The three screengrabs of the example microstepping program for the DRV8825 running on a Micromite. From left to right there is the main menu at power-up, the SET FUNCT sub menu (which determine how the drive pulses should be sent) and then the SET MODE sub menu (which is used to select the stepping mode).

On the output side, the motor windings are connected to the A1, A2, B1 and B2 pins, while the motor supply is connected to the V_{MA} (+12V) and GND pins. The two GND pins are also connected together, and on to a GND pin on the Micromite. This is done to ensure that both the module and the Micromite have a common ground.

An electrolytic capacitor of at least 100µF must be connected between the V_{MA} and GND pins of the module, as shown in Fig.8.

This is to provide a low impedance reservoir from which the module's H-bridges can draw current pulses – without any impedance from inductance in the power leads.

The USB-UART bridge module at top centre in Fig.8 is to program the Micromite from your PC, as well as to provide the Micromite with 5V DC.

Note that while the DRV8825 module comes with a tiny (9 x 9 x 5mm) finned heatsink which can be attached to the top of the DRV8825 chip using an adhesive patch, it is unnecessary when driving a small stepper motor from a 12V supply.

Presumably, it would be required if the module is driving a reasonably large stepper motor with windings drawing over 1A from a 24V supply.

In our test, the winding current was only about 330mA and even without the extra heatsink, the DRV8825 became only barely warm. The module PCB provides copper patches on both sides under the chip, linked by an array of vias. So it already has a useful amount of heatsinking.

After studying TI's datasheet and application notes, I was able to write a Micromite program to control a stepper via the DRV8825 module.

This program is named "DRV8825 stepper driving program.bas" and you can download it from the SILICON CHIP website.

When loaded onto a Micromite with LCD BackPack, at power-up it will present you with the main screen with six touch buttons, shown in Screen 1. The buttons are labelled SET FUNCT, SET MODE, < DIR, DIR >, START and STOP. Pressing SET FUNCT loads the SELECT FUNCTION screen shown in Screen 2.

This lets you choose from one of five functions: SINGLE (send a single step pulse each time), CONTIN (send a large number of step pulses), 1/2 REV (send pulses for a half revolution of the motor), FULL REV (send pulses for a full revolution), and FWD-REV (send pulses for one full revolution in one

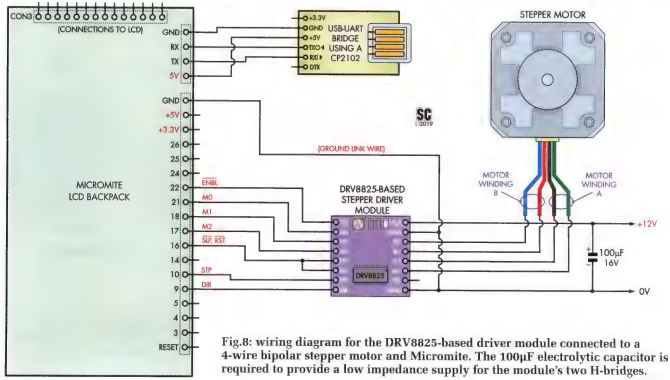


Fig.8: wiring diagram for the DRV8825-based driver module connected to a 4-wire bipolar stepper motor and Micromite. The 100µF electrolytic capacitor is required to provide a low impedance supply for the module's two H-bridges.

direction, followed by pulses to make the motor return in the opposite direction to its original position).

The sixth button on this screen is labelled RETURN, allowing you to get back to the main screen without changing the existing selection.

If you press the SET MODE button on the main screen, you'll be presented with the SELECT STEPPING MODE screen shown in Screen 3. This allows you to select one of the six stepping modes provided by the DRV8825: FULL STEP, HALF STEP, 1/4 STEP, 1/8 STEP, 1/16 STEP or 1/32 STEP.

Touching any one of these buttons selects the desired mode and switches you back to the main screen.

The two red buttons on the main screen are used to select the direction of motor rotation. And touching the START button at lower left should result in the motor performing the selected function, using steps of the mode you've selected. The STOP button allows you to stop the motor at any time.

This program demonstrates a fair number of possibilities when it comes to using the Micromite to control a stepper motor using the DRV8825 module.

Some useful links on each of the modules are listed below:

www.st.com/en/motor-drivers/l298
www.ti.com/product/DRV8825
siliconchip.com.au/link/aama

Low-cost stepper motors currently available

Currently, there are quite a few new stepper motors available via eBay and other online sources.

Here's a sample of those we found in the standard NEMA sizes, together with their price range:

NEMA 11: around $11 each
NEMA 17: $12-22 each or five for $38-69
NEMA 23: around $50 each

There were also many small non-NEMA steppers available at much lower prices.

For example, a 28BYJ-48 5V unipolar stepper motor bundled with a ULN2003 driver module was around $3.22 each. SC

DID YOU MISS OUT?

Is there a particular project in SILICON CHIP that you wanted to read – but missed that issue? Or perhaps a feature that really interests you?

GRAB A BACK ISSUE . . . WHILE THEY LAST!

The SILICON CHIP Online Shop carries back issues for all months (with some exceptions!) from 1997 to date. Some popular issues are sold out, and some months are getting quite low.

But if you want a particular issue, you can order it for just $12.00 INCLUDING P&P* – while stocks last!

The following issues are still available (at time of going to press):

1997 – all except August and September
1998 – all except March
1999 – all except February
2000 – all except April
2001 – all except October & December
2002 – all except June & July
2003 – all still available
2004 – all still available
2005 – all still available
2006 – all except January & October
2007 – all still available
2008 – all still available
2009 – all still available
2010 – all still available
2011 – all still available
2012 – all except December
2013 – all except February
2014 – all except January
2015 – all still available
2016 – all still available
2017 – all still available
2018 – all still available

HOW TO ORDER WITH YOUR CREDIT/DEBIT CARD#:
Don't forget to let us know which issues you require!
Via email: **silchip@siliconchip.com.au** (24 hours a day)
Via the net: **siliconchip.com.au/shop/** (24 hours a day)
By mail: **Silicon Chip, PO Box 139, Collaroy NSW 2097**
By phone: **(02) 9939 3295;** Mon-Fri 9am to 4.30pm
** Australia only. Oseas? email for a quote*
 # Visa/Mastercard only.

OH NO! THE BACK ISSUE YOU WANT IS SOLD OUT!

DON'T PANIC AND STAY CALM! We can still help you! The SILICON CHIP website (siliconchip.com.au) houses complete issues from mid 1997 on. You can browse a preview version – and if it's what you want, you can purchase a digital edition (complete magazine) .

Full details are given where you browse the issue. And if you're a current digital edition subscriber, there are even more attractive rates!

SPEAKING OF SUBSCRIBING . . .

That's the one way to guarantee you'll never miss an issue! Not only that, you'll SAVE money on the over-the-counter price.

Full details are at **siliconchip.com.au/shop/subscriptions**

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Making a cheap WiFi-controlled relay board work

I recently ordered a tiny ESP8266 relay switch module from AliExpress. The vendor said that it comes pre-programmed and I can use an Android phone app to operate it. But despite several attempts with several different Android apps, I couldn't get it to do anything! The device connects to my WiFi router and is allocated an IP address but nothing happens after that.

Utterly frustrated, I decided to write my own software to program its onboard ESP8266 processor, just so I could get it to work. My new code causes the ESP8266 to appear with a fixed IP address on the local network and you can then connect to it with any web browser. On and off buttons appear which allow you to switch the relay.

I also added a relay status display and a counter to show how many times you've accessed the control page.

Since the device now has a static IP address, you can set up port forwarding on your router to allow for external access to this page (assuming that your public IP address is static, or you're using a dynamic DNS service). Be careful though, since nothing is stopping some random person anywhere in the world from controlling your relay if they figure out the IP address and port combination!

Like the popular ESP-01 board (described in our April 2018 issue; see **siliconchip.com.au/Article/11042**), this board has an 8-pin header and that allows you to reprogram its onboard ESP8266 chip with my new software.

You need a few components to reprogram the chip but it's pretty simple. For software, use the Arduino IDE with the ESP8266 board files loaded.

The supplied .ino sketch file (available for download from **siliconchip.com.au**) will open right up in the Arduino IDE. You will need to change the static IP address to your desired IP address and port (make sure the address is on the correct subnet and not used by any other device). You will also need to set the WiFi SSID and password variables to the correct values for your network.

Having set all those values, check that you have selected the ESP-01 board file via the IDE, then verify the program (CTRL+R) to make sure there are no errors.

You will need a USB/serial adaptor such as one based on the ubiquitous CP2102 for programming. Plug this into your PC and select it as the active port in the Arduino IDE.

The breadboard arrangement shown here is reproduced from the Clayton's GPS Time Source article, also from the April 2018 issue. It shows how to create a programming rig for an ESP-01 board using just a breadboard, some jumper wires and a couple of resistors.

The only real difference between the ESP-01 and the ESP8266 relay module is that the former has a male 4x2 pin header while the latter has a female 4x2 pin socket. But the pinout is the same.

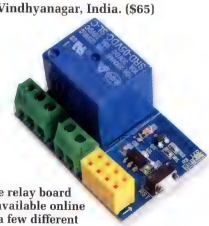
You can figure out which pin is pin 1 by probing diagonally opposite pins with a DMM set to measure volts until you get a reading of +3.3V with the module powered up. In that case, the black probe is on pin 1 and the red probe is on pin 8. You can then proceed to wire up the module to the breadboard programming adaptor.

As stated on the diagram, to enter programming mode, hold the blue wire to ground and then touch the green wire to ground. While still holding the blue wire to ground, select the Upload (CTRL+U) option in the Arduino IDE. If all goes well, you will then see the progress as it uploads the new code, shown at the bottom of the IDE window.

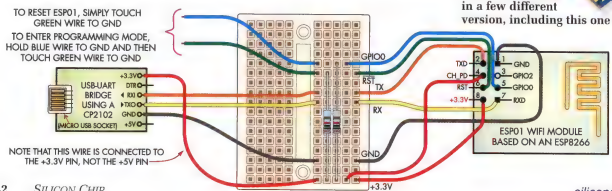
When you go to the specified IP address and port you should be presented with a webpage comprising of an on/off button. For example, if you chose 192.168.0.100 as the IP address and 8080 as the port, open a web browser and go to http://192.168.0.100:8080

For those who wish to make this accessible over the internet, an appropriate security mechanism (eg, password control) is left as an exercise to the reader.

Bera Somnath,
Vindhyanagar, India. ($65)



The relay board is available online in a few different version, including this one above.



Modular Quiz Buzzer system

This quiz buzzer system is expandable and doesn't use any microprocessors. You build a single buzzer module and however many player modules are required (it has been tested with four).

The modules are connected via a two-wire bus. Each player has a push-button and LED indicator, and the fastest one to press their button blocks all the others, triggering the piezo buzzer.

The buzzer module provides power to the whole system from a pack of four AA cells. Switch S1 is the master power switch. With it on, DC power is fed to all the player modules via a 390Ω resistor and the twin lead daisy chain.

When a player presses pushbutton switch S2, this causes a voltage to appear at pin 3 of IC2a, an LM358 op amp that is wired as a comparator. A 1.8V reference voltage is fed to its pin 2 inverting input, generated by LED3. Assuming the full 6V from the battery is being fed to that player's module, approximately 2.2V (6V × 39kΩ ÷ [68kΩ + 39kΩ]) will appear at its pin 3 non-inverting input.

Since the voltage at pin 3 is higher than the voltage at pin 2, output pin 1 will swing high, triggering SCR1 via the 1kΩ gate current-limiting resistor. SCR1 will therefore latch on, lighting up LED2, which receives around 19mA due to the 220Ω series current-limiting resistor.

And since the current to light LED1 flows from the battery in the buzzer module, through a 390Ω resistor, the voltage across all player modules drops until diode D1 in the buzzer module becomes forward-biased. D1 is in series with the infrared LED inside OPTO1, giving a total forward voltage of around 1.7V. That results in a supply voltage for each player module of around 4.3V.

Other players can no longer trigger their SCR, since if they press their S2, the voltage at pin 3 of their IC2a will only be about 1.57V (4.3V × 39kΩ ÷ [68kΩ + 39kΩ]), below the voltage at pin 2 and therefore the output of IC2a will not go high. This remains the case until the buzzer module is switched off and on again, cutting power to the latched SCR and resetting the state of the game.

Since the infrared LED in OPTO1 is forward-biased whenever any of the player LEDs are lit, current can flow from its pin 6 to pin 4, powering Schmitt trigger NAND gates IC1a-IC1d and also lighting LED1.

Initially, IC1a's inputs are held low by the discharged 10µF capacitor and so its output pin 3 is high. The 10µF capacitor takes about one second to charge, then IC1a's output goes low.

During this second that its output is high, the Schmitt trigger inverter formed by the three other paralleled NAND gates oscillates at around 550Hz, producing a tone from the 8Ω speaker. The gates are paralleled to provide sufficient output current to drive the 8Ω speaker via a 100µF DC-blocking capacitor.

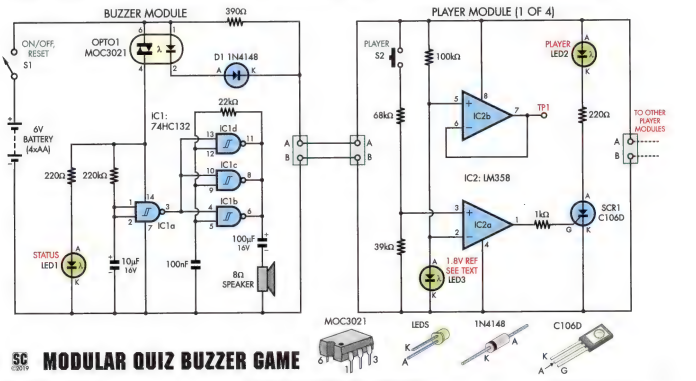
Since each player module is effectively connected in parallel, you can connect however many you need. But note that you may need to reduce the value of the 390Ω resistor slightly if you connect more than four player modules. The minimum possible value is around 100Ω. Below that, it would be possible for multiple players to light their LEDs simultaneously.

The spare half of each op amp in the player modules is wired up as a voltage follower, to allow the 1.8V reference voltage to be measured without loading up the reference circuit.

Note that you could wire a normally closed pushbutton switch in series with S1 to provide a reset button on the buzzer module, but you would need to hold it down for several seconds to ensure the whole circuit is reset properly.

This project can be assembled on your choice of prototyping boards and housed in small Jiffy boxes. The buzzer module requires a larger enclosure to fit the speaker and battery. For the player buttons, use tactile or snap-action contact switches. The player buttons (S2) and LEDs (LED2) can be separate parts, or you can use a suitable illuminated pushbutton.

Ian Robertson,
Engadine, NSW. ($65)



"Crystal set" uses an electret microphone as a detector

A crystal set radio receiver is a fun first project to get into electronics. One of the really amazing aspects is that it needs no power supply; it uses the power from the received radio waves to work!

This circuit is a twist on the age-old design and can be built from commonly available, low-cost parts.

I was intrigued by the Moki-brand "noise isolation earphones" I saw for sale in a local supermarket. They have used 10mm super magnet drivers with 32Ω impedance coils to give a very high sensitivity of 118±3dB @ 1mW and 1kHz.

This is way too sensitive to use with modern powdered devices but has the advantage when used in a crystal set of allowing you to get a decent amount of sound from a tiny induced voltage.

Traditionally, the earphones used with crystal sets are high impedance types, to avoid loading the detector up too much, which would cause a lot of distortion.

So I had to come up with a way to overcome the low impedance in order to use these earbuds. A transformer could be used to transform the impedance but it adds cost and complexity, and would possibly reduce efficiency.

I read an article in QST Magazine (January 2007) showing how three-terminal zero gate threshold voltage Mosfets can be used as detectors, with the source tapped at a lower impedance position on the coil, allowing for the use of a low-impedance earbud.

Unfortunately, these devices are relatively expensive. You can see a discussion of this technique at **siliconchip.com.au/link/aaky**

More conventional Mosfets and diodes can be used as detectors with biasing but you need a battery or DC power supply to provide the bias voltage. Common JFETs and some dual-gate Mosfets could potentially be used as detectors without biasing but the resulting distortion may still be objectionable and the impedance matching would not be perfect.

This brought me to the ideal solution, using a low-noise electret microphone element. These are readily available and cheap, with an internal JFET that is already biased to the threshold of conduction by the electret membrane and an internal high-value resistor.

Some electrets have three terminals: source, drain and the gate which is connected to the case or shield. Others have two terminals, with the case soldered to the source electrode. Two-terminal devices can usually be converted to three terminals by cutting the case-to-source track(s).

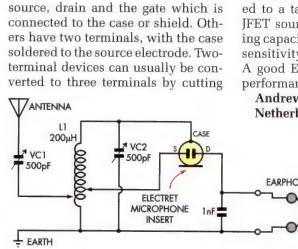
I have found the Altronics C0170 three-terminal electret to make an excellent detector, with the case wired to the top of the coil and thus capacitively coupled to the internal gate, as shown in the circuit diagram. The gate capacitance is very low so the full received signal can be applied to it and loading is minimal.

The source is connected to a low impedance tap on the coil and the drain to one end of the Moki earphones mentioned above.

The resulting circuit is not particularly microphonic (despite the use of a microphone in the detector role). The earphones could potentially be wired in series, tip to ring, but will then be out of phase. I cut open and re-wired my pair to be in phase.

With a long wire antenna connected to a tap on the coil between the JFET source tap and Earth, and tuning capacitor in parallel with the coil, sensitivity and selectivity are high. A good Earth is required for decent performance.

Andrew Russell,
Netherby, SA. ($75)



SC ©2016 **ELECTRET MIC 'CRYSTAL SET'**

Editor's note: you can still get a more traditional crystal radio kit from Jaycar (Cat KV3540) although it uses a packaged diode rather than a "cat's whisker".

Four-channel sound system using a single woofer

A traditional stereo hifi sound system uses two full-range amplifiers, driving a pair of speakers, each of which contains at least two (and possibly three or more) drivers.

The separate drivers are used to reproduce different parts of the frequency spectrum. For example, a two-way speaker system incorporates a tweeter to reproduce high frequencies and a woofer to reproduce low frequencies.

This is necessary because a single driver usually cannot reproduce the full range of audible frequencies and those that can do not usually have a particularly flat response or low distortion.

However, there are disadvantages of the traditional system, such as the difficulty of designing the combination of drivers, cabinets and crossovers to give a reasonably flat and low-distortion response, losses in the (usually passive) crossovers and the fact that a single amplifier must produce the power for all the drivers in one cabinet.

This sound system takes a different approach, where the low frequencies are reproduced using a single woofer, akin to a subwoofer; but unlike a subwoofer, it is not limited to very low (almost sub-audible) frequencies. As low-frequency sounds have long wavelengths, most of the directional information our ears pick up come from the higher frequencies.

This approach won't necessarily provide the same sound quality as a true hifi system but it can result in reasonably good sound quality at minimal cost.

The basic idea with this system is that one big mono bass speaker performs better than two smaller ones. There is little to be gained from having the bass in stereo.

Also, if all the speakers share the same box, the bass can modulate the other drivers, causing extra distortion. By separating the midrange and treble from the bass, the left and right

speaker cabinets can, therefore, be small and sealed – there are no large cone excursions or low frequencies to handle.

A similar unit can also be used for a centre channel, to improve speech intelligibility and directionality in a home theatre system.

The bass amplifier only needs a 10-250Hz power bandwidth, which is ideal for a Class-D switching amplifier. You could use the Studio 350 (350W into 4Ω; January-February 2004; siliconchip.com.au/Series/97) or the CLASSiC-D (250W into 4Ω; November-December 2012; siliconchip.com.au/Series/17).

Three smaller amplifiers can then be used to drive the left, right and centre speakers, which can be "bookshelf" speakers. These amplifiers need a 150Hz-20kHz power bandwidth; a good choice is the LM3886 50W amplifier module.

Most of the circuit shown overleaf consists of the op amps and associated components, configured as active filters, which separate out the various audio frequencies to feed to the individual amplifiers.

The stereo audio signal is fed into CON1 and CON2 and then via non-polarised coupling capacitors to op amps IC3b and IC5b. These act as simple buffers, to drive the following fourth-order high-pass filters based around IC4 (left channel) and IC6 (right channel). They have a corner frequencies of 150Hz.

The signal from these filters passes through individual volume controls (VR2 and VR3) and then into op amps IC7b and IC9b which provide two times gain.

These then drive the left and right channel amplifiers via 150Ω series resistors (for stability) and 4.7μF non-polarised coupling capacitors.

The signals from CON1 and CON2 are also mixed using a pair of 47kΩ resistors to give a mono signal and this passes to IC3a via a 10μF coupling capacitor, which is the start of the bass signal chain, and also to IC5a via a 4.7μF coupling capacitor, which is the centre channel signal chain.

The centre channel filtering is identical to that of the left and right channels and after passing through buffer IC5a, high-pass filters IC8a and IC8b and gain stage IC9a, the signal is fed to another identical power amplifier to drive the centre speaker.

The bass network starts with a Baxandall-style feedback-based volume control using potentiometer VR1, the output of which is fed into a fourth-order 10Hz high-pass filter (IC1) and then into a fourth-order 150Hz low-pass filter (IC2), another gain stage (IC7a, gain = 3) and then to the bass output, to be fed to the woofer power amplifier.

All four outputs are provided with LM3886 power amplifiers, although you could omit some of these if external amplifier(s) are being fed from one or more of the line outputs instead.

The LM3886 is essentially a power op amp, running off ±35V supply rails derived from a 25-0-25 transformer of at least 100VA (ideally 160VA or more), a bridge rectifier comprising 1N5404 3A diodes and a pair of 10,000μF filter capacitors.

Each amplifier has its own pair of 100μF bypass capacitors for each rail, plus some other components as follows.

The 5.6Ω resistor and 100nF capacitor from each amplifier output to ground is a Zobel network, necessary to stabilise the amplifier.

The output inductor and parallel resistor are also important for stability as they isolate the amplifiers from any external capacitance. The resistor reduces the Q of the inductor to eliminate ringing.

The components connected to pin 8 (mute) provide a power-on delay and gentle power-off behaviour for dethumping.

The 20kΩ resistor from pin 3 (output) to pin 9 (inverting input), and the 1kΩ resistor from pin 9 to ground (via a 47μF capacitor) set the gain to 21 times.

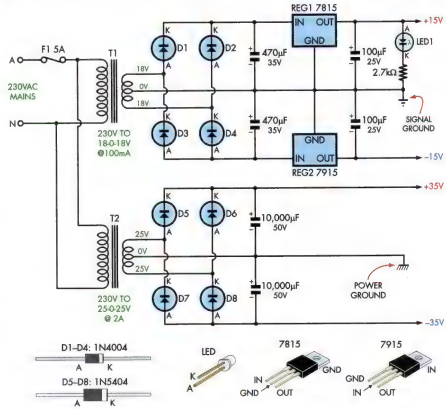
The 47μF capacitor reduces the DC gain to one so that the input offset voltage is not amplified.

The two extra components across the 20kΩ feedback resistor create an extra pole in the loop response, for additional high-frequency stability.

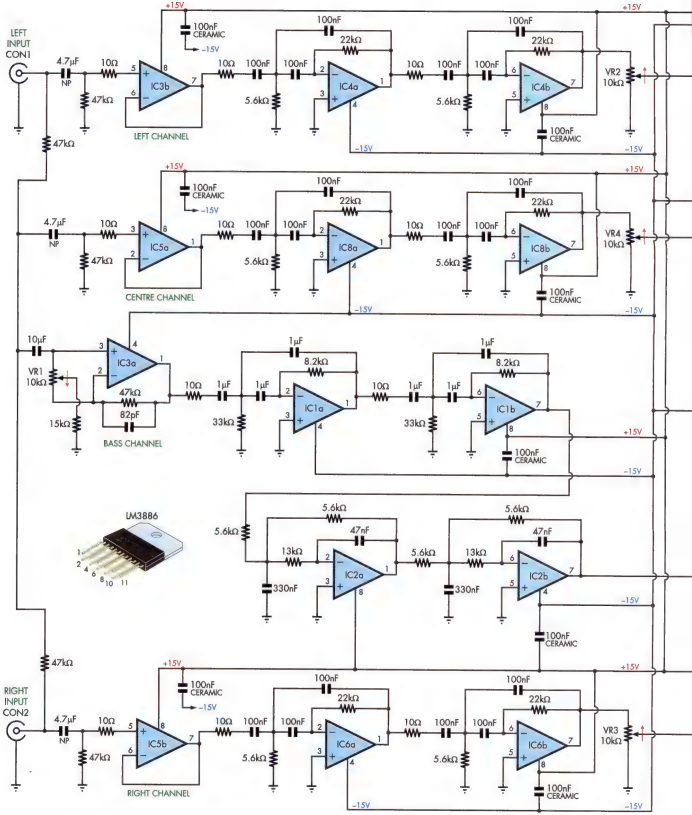
The 220pF capacitor between inverting input pin 9 and non-inverting input pin 10 provides EMI suppression and reduces bandwidth and high frequencies to avoid quasi-saturation oscillations of the internal output transistors.

A 10Ω resistor between the signal ground and power supply ground improves ripple rejection.

The power supply also incorporates a smaller 18-0-18 transformer with a bridge rectifier, filter and regulators to provide stable ±15V rails for the



SC COMPACT FOUR CHANNEL AUDIO SYSTEM POWER SUPPLY

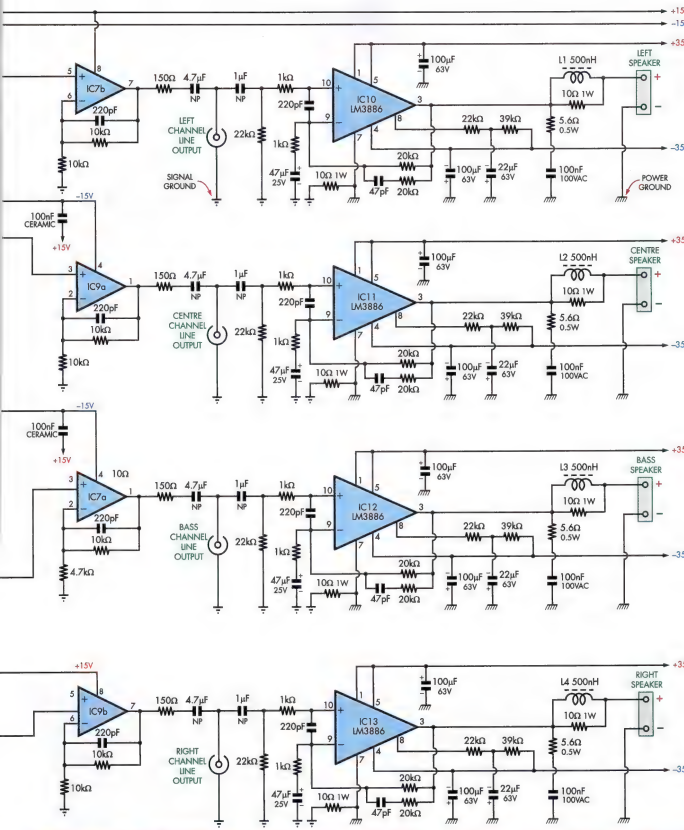


SC COMPACT FOUR CHANNEL AUDIO SYSTEM

op amps. LED1 is connected across these supply rails, with a 2.7kΩ current-limiting resistor, as a power-on indicator.

While not shown in this circuit, a Loudspeaker Protector should be used for each channel. We published suitable designs in the October 2011 (siliconchip.com.au/Article/9398) and November 2015 (siliconchip.com.au/Article/9398) issues. Both are stereo so two would be required to protect all four channels.

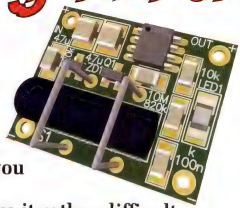
John Russull,
Cambodia. ($100)



Circuit Ideas Wanted

Got an interesting original circuit that you have cleverly devised? We will pay good money to feature it in Circuit Notebook. We can pay you by electronic funds transfer, cheque or direct to your PayPal account. Or you can use the funds to purchase anything from the Silicon Chip Online Store, including PCBs and components, back issues, subscriptions or whatever. Email your circuit and descriptive text to editor@siliconchip.com.au

Motion-Triggered 12V Switch



This simple circuit switches on a 12V circuit when it detects acceleration or vibration. It has many possible uses but it's especially handy if you have an always-on car accessory power socket. These are becoming quite common but they make it rather difficult to use a standard dashcam or GPS. This project solves that problem and it can be built in a couple of hours.

by Nicholas Vinen

This solves a problem that shouldn't exist – but it does, and it's really annoying. While it has many different potential uses, I designed it specifically to switch a dash-mounted video camera ("dashcam") on automatically when you start driving the car, then off again when you stop.

But, you are wondering, don't dashcams already do that? Aren't they powered on and off automatically as the accessory socket switches on and off with the vehicle ignition?

Of course they are... in most cases.

The problem

But for whatever reason, the accessory power socket ("cigarette lighter") in my wife's car does not switch on and off with the ignition. Since it's always on, after driving, her dashcam runs until the car's battery is almost flat, at which point the accessory power socket shuts off.

As if that wasn't annoying enough, when (if!) you start the car the next time, it doesn't come back on automatically.

You have to remember to unplug and re-plug the dashcam to get it to go on. Somehow, I doubt we are the only people with this problem.

Obviously, this is not very satisfactory. I guess the power socket remains on so you can charge your phone (or run other accessories) with the ignition off.

But I think this "feature" causes more problems than it solves.

And while the socket is no doubt under the control of the body computer, I can't find any way to set it back to the old-fashioned scheme – which worked fine, thank you very much. There's no obvious physical or software switch to do so.

Hence, I had to come up with this project as a way to switch the dashcam on and off automatically, while drawing very little power when it is off, so the vehicle's battery still has a reasonable charge after sitting for a few days.

The solution

The obvious solution was to sense when the car is running via the battery

It's a problem that shouldn't exist . . . but it does if your cigarette lighter socket doesn't power off when the ignition is off!

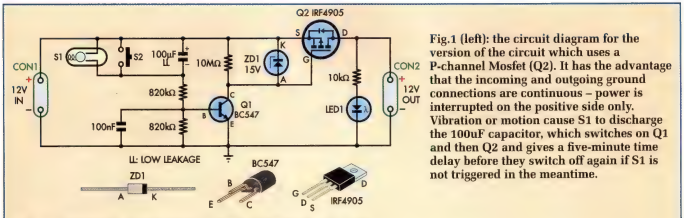


Fig.1 (left): the circuit diagram for the version of the circuit which uses a P-channel Mosfet (Q2). It has the advantage that the incoming and outgoing ground connections are continuous – power is interrupted on the positive side only. Vibration or motion cause S1 to discharge the 100uF capacitor, which switches on Q1 and then Q2 and gives a five-minute time delay before they switch off again if S1 is not triggered in the meantime.

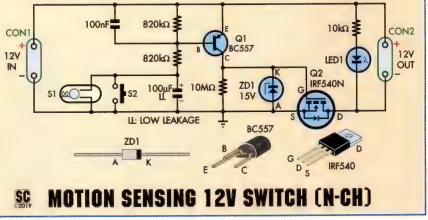


Fig.2 (right): this version of the circuit uses an N-channel Mosfet for Q2 instead. If you compare it to Fig.1, you can see that the changes essentially involve flipping everything upside-down to deal with the different gate drive polarity requirement of this Mosfet. Otherwise, it works the same, except for the fact that it breaks the ground connection between the input and output side to switch the connected device(s) off.

voltage. But another "feature" of this otherwise fine vehicle is that it doesn't always charge the battery while running. So I had to find another way.

My next idea was to have an accelerometer that's monitored by a low-power microcontroller, waiting for the vehicle to move before switching on power to the dashcam.

It could then leave the power on as long as the vehicle was in motion (with a timer, so it doesn't go off when you're stationary for a couple of minutes at a time), and switch it off at the end of the trip.

But I realised that I was over-complicating matters. There is a much simpler solution – using a vibration switch.

These small, low-cost devices consist of a spring surrounding a metal post inside a can. At rest, the spring doesn't touch the post but any movement or vibration causes it to come into contact, closing the switch contacts. Less sensitive versions use stiffer springs.

So it's just a matter of using that switch to trigger a separate device to switch 12V power to the dashcam, and adding a timer to delay switch-off.

The design presented here uses just nine (mandatory) components, plus the accessory plug and socket, to achieve that. That's certainly a lot simpler than the accelerometer-based solution would have been!

I set the time-out period to about five minutes. Even in the worst traffic, you usually are not stationary for that long.

Circuit description

Refer now to the circuit diagram shown in Fig.1. This uses a P-channel Mosfet as the switch (Q2) so that it's the +12V line which is switched.

The heart of the project is one of these tiny vibration switches, shown with a $2 coin for a size reference (and they don't cost much more than $2 anyway!) On the left is the Soyo SW-1801P from Pakronics; on the right is the CM1800-1 from element14.

The ground connection is unbroken. This may be important in some cases, where your dashcam might connect elsewhere in the vehicle and could have a separate ground connection to the chassis.

In that case, switching the negative end of the power supply wouldn't do anything useful.

The 100µF capacitor provides the five-minute delay, in combination with the two 820kΩ resistors between its negative end and ground. Initially, when power is applied, the 100µF capacitor is discharged. That means that current flows through it and the upper 820kΩ resistor, to the base of NPN transistor Q1, as it charges.

Q1 therefore switches on, pulling the gate of Mosfet Q2 low, close to 0V. As a result, Q2's channel conducts current from the 12V positive input to the 12V positive output, powering the dashcam.

As the 100µF capacitor charges, after about five minutes, the base of Q1 drops below about 0.5V. Q1 then begins to switch off, allowing the gate of Q2 to be pulled up to +12V by the 10MΩ resistor, switching Q2 off.

The reason we do not have the ca-

NOTE: VIEW OF BOTH BOARDS IS FROM THE TOP (COMPONENT) SIDE, AS WE NORMALLY SHOW WITH PCB LAYOUTS. THE COPPER STRIPS ARE ON THE UNDERSIDE OF THE BOARD, AS IF YOU WERE LOOKING THROUGH THE BOARD WITH X-RAY VISION.

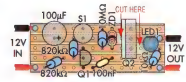


Fig.3: use this diagram as a guide to building the P-channel version of the circuit on a piece of stripboard. Note carefully the two locations where the tracks are broken, with a knife or drill. Watch out to avoid the possibility of component leads or exposed metal tabs shorting to each other if the components are moved slightly.

Fig.4: this is the stripboard layout for the N-channel version of the circuit. As with the circuit diagram, this is basically just a flipped version of Fig.3 to compensate for the difference in behaviour between an N-channel and P-channel Mosfet.

pacitor directly on the gate of Q2 is that that would cause Q2 to switch off slowly, over about 30 seconds, due to the slow charging rate of that capacitor. During this time, the Mosfet would be in partial conduction and so it would have a high dissipation, heating up and possibly burning out.

Since Q1 is a bipolar junction transistor, and its load impedance is so high, it only takes a few millivolts of change in its base voltage to go from fully on to fully off. That, in turn, allows Q2 to switch off fast, typically spending less than one second in partial conduction, so it doesn't heat up too much during switch-off.

The 100µF capacitor needs to be a low leakage type due to the high charging impedance of 820kΩ + 820kΩ = 1.64MΩ. Otherwise, it will never fully charge and so Q2 may never switch off. Alternatively you can use two 47µF tantalum capacitors in parallel (as we did on our prototype) although a low-leakage electrolytic will probably be cheaper.

ZD1 protects the gate of Q2 from excessive voltages, which may be due to power supply spikes in the system. It clamps the gate to around +16V and -1V, well within its ±20V rating.

The current through ZD1 is limited by the relatively high base impedance of Q1. The maximum base current with a 14.4V supply is (14.4V – 0.5V) ÷ 820kΩ = 17µA. The highest beta for a BC547 is around 800 at 2mA but it's less than half that at very low currents, so the maximum figure is around 400. That translates into a collector current of no more than 17µA x 400 = 6.8mA.

That's more than enough current to pull the gate of Q2 to 0V but low enough that neither Q1 nor ZD1 will be damaged if the supply voltage is high enough for ZD1 to conduct. Even if the supply voltage is considerably higher (which it would need to be, for ZD1 to conduct), nothing is going to burn out.

The 100nF capacitor between the base and emitter of Q1 is important since the supply voltage in a vehicle can vary a great deal, from around 10V when cranking up to around 14.4V when the battery is being charged. And there can also be a great deal of noise and some significant voltage spikes on the supply line.

This 100nF capacitor prevents supply spikes from causing Q1 to switch off briefly, which would cut power to the dashcam.

Optional components

Pushbutton switch S2 is shown wired across the vibration switch, as a manual means of forcing the unit to switch on. But you will notice that we have left it out of our PCB designs. That's because merely bumping the PCB is enough to switch the unit on; so it would probably come on even before you could press S2. So while it makes sense in theory, in practice, you don't need it.

LED1 and its 10kΩ current-limiting resistor are wired across the output so you can easily see if the unit's output is switched on. This only adds about 1mA to the current consumption when the unit is on. It's handy for debugging and testing, but you don't need it, so you could leave it off your version.

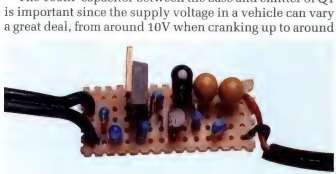
By the way, the circuit draws almost no power when off – basically just the leakage current of the 100µF capacitor, which is usually around 1µA. So it will not affect your vehicle's battery life.

The vehicle itself will typically draw around 10mA, plus another 10mA or so of battery self-discharge, for a total of around 20mA which is 20,000 times more than this circuit draws.

Alternative versions

Fig.2 shows how you can build the circuit using an N-channel Mosfet instead of a P-channel Mosfet. Essentially, everything is inverted. Q1 changes from an NPN transistor to a PNP transistor. All the other parts are the same, just connected differently.

You might want to build this version just because it's



This photo is taken from the opposite side of the stripboard than the diagram above (ie, output on left and input on right) to more clearly show the smaller components which could be otherwise hidden.

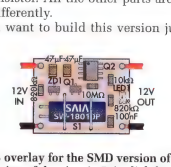


Fig.5: the PCB overlay for the SMD version of Fig.1, the P-channel version of the circuit. It is slightly taller but it is narrower and much thinner, so it should give a more compact result. Mosfet Q2 is in an 8-pin SOIC package which is easy to solder, as are all the other components. Note the two 47µF capacitors connected in parallel, which are used instead of a single 100µF capacitor which would be larger.

easier and cheaper to get a high-current N-channel Mosfet. You may even have one lying around somewhere.

But keep in mind that it interrupts the negative power connection, rather than the positive connection, meaning you can only really use it to switch devices which do not connect to any other powered devices (unless they get their power from the same socket).

As there are so few components in this circuit, I built mine on stripboard (or "Veroboard") and you could do the same. The stripboard component layouts are shown in Figs.3 and 4.

SMD PCB version

However, many people don't like stripboard (to be honest, I'm normally one of them!), so I also designed a small PCB for the P-channel version **only**.

This uses SMD parts (see Fig.5) so has the advantage of being much shorter and thinner, at just 25 x 20 x 5mm. It's therefore suitable for encapsulation in a smaller (~16mm diameter) piece of heatshrink tubing, making it easy to tuck away.

The only through-hole part used is the vibration sensor itself, S1. This is laid on its side and held down to the board using a couple of wire straps to keep everything nice and rigid, minimising the overall size of the module.

The only difference in the circuit is that we've used two parallel 47µF 16V SMD ceramic capacitors rather than a single 100µF electrolytic, as 100µF 16V SMD capacitors tend to be larger and more expensive. In addition to being compact, ceramic capacitors are very reliable and heat-tolerant compared to electrolytics.

We won't go into any great details regarding the assembly of the SMD version, although we have an alternative SMD parts list at right.

If you want to build this version, you can purchase the short form kit (which includes the PCB and all on-board parts) from our online shop (Cat SC4851). Solder them in place where shown in Fig.5.

Construction

One critical aspect of construction is to note that one of the leads of the vibration sensor may be extremely thin and easy to break.

It depends on exactly which sensor you use; we used a very common type (SW-18010P) and managed to break one lead while testing it. Interestingly, the other lead is really thick and presumably intended to allow it to be rigidly mounted to the board.

The layout for the P-channel version that I built is shown in Fig.3, with the layout for the N-channel version in Fig.4. As with the circuits, they are almost a mirror-image of each other.

Both designs require tracks to be cut in two places; the cuts are shown on either side of Q2. Look closely at Fig.3 and Fig.4; the breaks are shown but they are visually subtle. You can make these cuts with a sharp knife but make sure you remove a fair bit of copper so they can't accidentally come in contact.

Some people prefer to use a ~4mm drill turned by hand but it needs to be sharp or it will not cut the copper. It probably wouldn't hurt if you actually drilled through the board but might weaken it slightly.

Having made the two track cuts, fit the components.

Parts list – 12V movement/vibration switch

P-channel version on strip board

1 piece of stripboard/Veroboard, five strips x 14 holes
1 Soyo SW-18010P vibration sensor, or similar (S1)
1 car accessory power extension cable, length to suit (cut in half to get cables with plug and socket on ends)
short lengths of various diameter heatshrink tubing

Semiconductors

1 BC547 NPN transistor (Q1)
1 IRF4905 P-channel Mosfet or equivalent (Q2)
1 blue 3mm LED (LED1
1 15V 0.4W or 1W zener diode (ZD1)

Capacitors

1 100µF 16V/25V low-leakage electrolytic ***or***
2 47µF 16V tantalum
1 100nF ceramic

Resistors (all 0.25W, 1% or 5%)

1 10MΩ *(brown black green brown or brown black black yellow brown)*
2 820kΩ *(grey red yellow brown or grey red black range brown)*
1 10kΩ *(brown black orange brown or brown black black red brown)*

Parts substitutions for N-channel version

1 BC557 PNP transistor (Q1)
1 IRF540N N-channel Mosfet or equivalent (Q2)

Parts for SMD version on PCB*

1 double-sided PCB, coded 05102191, 25.4 x 19.5mm
1 Soyo SW-18010P vibration sensor, or similar (S1)
1 car accessory power extension cable

Semiconductors

1 AO4421 P-channel Mosfet or equivalent, SOIC-8 (Q1)
1 BC847 NPN transistor, SOT-32 (Q2)
1 blue 3216/1206 LED (LED1)
1 15V 0.25W zener diode, SOT-23 (ZD1)

Capacitors

2 47µF 16V X5R ceramic, SMD 3226/1210 package
1 100nF 50V X7R ceramic, SMD 3216/1206 package

Resistors (all SMD 3216/1206 package, 1%)

1 10MΩ 2 820kΩ 1 10kΩ

***Where to get the SMD short-form kit:**

(Includes PCB and all on-board parts): Cat SC4851 from the Silicon Chip Online Shop (**siliconchip.com.au/shop**)

Where to get the vibration sensor:

The Silicon Chip Online Shop stocks the SW-18010P for $1 each (Cat SC4852). Our standard $10 p&p charge *per order* applies – it pays to order several things at once!

Pakronics (**www.pakronics.com.au**) have two Vibration Sensors in stock: the recommended Soyo SW-1801 P (Cat ADA1766), described as "easy to trigger", plus a "hard to trigger (ie, less sensitive) Cat ADA 1767. Both are priced at $3.36 plus GST and freight.

Alternatively, element14 (**au.element14.com**) has a range of slightly different "Comus" vibration switches (Cat 607253 and 540626) which could also be used in this project. Both are priced at $4.06 plus GST and freight.

(These sensors are the ones in the photo on page 49 – the Soyo SW-18010P on the left and the Comus [element14] on the right.)

The axial components (resistors and zener diodes) are all mounted with their leads 0.2" or 5.08mm apart, so they will need to have their leads bent so that they sit on the board in a semi-vertical position.

You have a choice of which side to place the component body; try to orientate them to avoid the possibility of component leads shorting together.

Make sure that the cathode stripe of ZD1 faces in the correct direction, as shown in Fig.3 and Fig.4.

The radial components (electrolytic capacitor, sensor, LED) have their leads soldered to adjacent tracks, 0.1" or 2.54mm apart, and this should be the natural pin spacing of these parts, making it easy.

Watch the orientation of the electrolytic capacitor; its positive lead is longer and should be located where shown with the + symbol in Fig.3 or Fig.4.

Similarly, you will probably not need to bend the leads of Q1 or Q2 as they will likely already have the requisite 0.1-inch spacing. Watch the orientation of both parts.

The orientation of the vibration sensor doesn't matter since it just acts as a switch.

Unfortunately we didn't have any clear heatshrink large enough – so red had to do! If there is any danger of any component being shorted (remember there's lots of movement under a dashboard) we'd also be inclined to crimp the edges of the heatshrink together before shrinking it.

Wiring it up

With all the components on the board, now you just need to wire up the plug and socket.

Rather than purchase a vehicle accessory (cigarette lighter) plug and socket separately, I bought a Jaycar Cat PP2006 "cigarette lighter double adaptor".

I then simply opened up the plug (undoing one screw and unscrewing the tip), removed the contacts, de-soldered the wires and pulled them through the strain-relief boot. That gave me two pre-wired sockets plus a plug, which I put aside since I already had a pre-wired accessory plug (Jaycar Cat PP1995).

The PP1995 plug wires went straight into the stripboard holes and I soldered them to the tracks, although I found I had to add some flux paste as I had difficulty getting the wires to take solder. I had to drill the board holes for the socket wires out to 1.5mm so after pushing the wires through the holes, I bent them over to come in contact with the copper strips and soldered them in place.

Testing

Ideally, testing should be done with a current-limited 12V DC supply in case there is a short circuit on the board, or one component has been installed incorrectly.

This can easily be achieved by connecting a 100Ω 5W or 220Ω 1W resistor in series with the supply. You can monitor the voltage across this resistor to get an idea of the circuit's current draw.

You can connect the supply to the cigarette lighter plug using a couple of alligator clip leads.

LED1 should light up immediately and you should get a reading of around 0.1-0.2V across the resistor due to the 1mA used to light it. If you leave board alone for about five minutes, being careful not to touch or bump it, LED1 should go out and the voltage across the safety resistor should drop to no more than a few millivolts.

When LED1 goes out, give the board a tap. The LED should switch back on. If it does, everything looks good.

If LED1 doesn't go out, or it doesn't go back one when you tap the board, check it carefully for short circuits. It's easy to accidentally short adjacent tracks on stripboard. It could also be due to a leaky electrolytic capacitor.

Use a DMM set to measure ohms and probe adjacent tracks. If you get a reading lower than 10 ohms, chances are you have a short circuit.

Also check your component placement and orientation, using Fig.3 or Fig.4 as a reference.

If it's working, remove the safety resistor and power the circuit directly from 12V. Measure the voltage at the socket. You should get a reading of +12V with the red probe touching the small contact area inside the base of the socket and the black probe on the inner metal surround.

You can then try plugging a vehicle accessory such as dashcam or GPS into the socket and check that it powers up correctly.

Finishing it off

Assuming all is well, disconnect everything and add some heatshrink insulation. It's a good idea to slip some tubing over the TO-220 package and shrink it down to ensure it can't short against any adjacent components. Do the same with any other components you think could short if they move or are bent.

Then slide larger diameter clear heatshrink tubing over the cigarette lighter plug and onto the board and shrink it down, so it can't short against any exposed metal that may be in the vehicle, or loose items like keys.

Installing it in the vehicle is simple. Just plug it into the accessory socket, plug in your dashcam, GPS or whatever, then find somewhere to tuck the circuit board away. It would be a good idea (at least initially) to put it somewhere where you can observe LED1, ideally from outside the vehicle, through a window.

Leave it for 5-10 minutes, somewhere where the vehicle is not going to be rocked by vehicles passing at high speeds, trucks, etc.

Then check to see if LED1 has gone out. If it has, open the door and get in. The motion from doing so will probably trigger the unit and switch LED1 back on. Otherwise, give the board a little nudge and check that it switches back on.

You may find the unit is too sensitive, eg, passing traffic often triggers it. In this case, you have two main options. The easiest is to add some cushioning around it like foam, to reduce the amount of movement and vibration transferred to it, reducing its sensitivity. You will need to experiment with the type and thickness of material to achieve a good result.

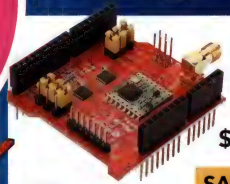
If that's no good, you will have to remove the vibration sensor and fit a less sensitive version.

But we've found that they are usually too insensitive so you're better off with the foam. SC

bringing you the latest in tech

hardcore electronics by **jaycar**

On sale 26 January to 23 February, 2016



long range data communications

NOW **$49.95**

SAVE $20

LoRa™ shield

Turn your Arduino® into a LoRa™ node capable of transmitting and receiving data over long distances. The perfect solution to your remote sensor and control projects.
XC4392 **WAS $69.95**

- Compatible with 3.3V or 5V I/O Arduino® board
- LoRa™ frequency band: 915MHz
- Low power consumption
- Includes external antenna (via I-Pex connector)

Introducing LoRa™, a powerful technology enabling secure wireless data communications over long distances (even several kilometres!!) without the need of a mobile GSM network. LoRa™ can be used in many outdoor or indoor applications, such as building automation, weather monitoring, irrigation systems control, smart metering, smart cities, and much more. LoRa™ has a low power consumption and AES128 security encryption.

Learn more at www.lora-alliance.org

LoRa™ IP gateway

Provides connectivity with 3G/4G access (USB 3G/4G dongle required), or via the WAN port. Faster and better, highly customisable using the open source OpenWrt system.

- LoRa™ and Wi-Fi connectivity
- Cloud-based remote management
- Detachable high-gain antenna

XC4394 **WAS $149**

NOW **$129**

SAVE $20

ONLY **$139**

ASUS

Dual band AC1900 USB Wi-Fi adaptor

Instantly upgrades your desktop or laptop to the newest 802.11ac technology with Wi-Fi speeds up to 1300 Mbps (5GHz) and 600 Mbps (2.4GHz). 3-position dual antenna system for outstanding reception. YN8436

ONLY **$249**

ASUS

AC1900 Wi-Fi range extender

Extend existing Wi-Fi range with speeds up to 1900Mbps (5GHz: 1300Mbps, 2.4GHz: 600Mbps). Quick and secure setup with its one-touch WPS button. YN8428

ONLY **$279**

ASUS

Powerline Wi-Fi extender kit

Extend fast wired and wireless networking anywhere in your home via existing electrical wiring. Simply plug in and enjoy fast, stable connections with no cable mess! Dual band with speed up to 1200Mbps. YN8434

ONLY **$389**

IO port ethernet switch with two 10Gbps ports ASUS

Plug-and-play convenience, no setup required for advanced home and business networking. 2 × ultra-fast 10Gbps ports for high speed applications. 8 × gigabit 100/1000Mbps ports for versatility. YN8430

19" rack mount cabinets

Ideal for IT or phone system installations, studios & PA systems, sound reinforcement etc. These cabinets are solid steel powder coated to provide high strength and rigidity. Flat packed for easy transport.

FROM **$59.95**

SAVE UP TO $20

Equipment cabinet aluminium front panel
1U HB5120 **WAS $74.95 NOW $59.95 SAVE $15**
2U HB5125 **WAS $119 NOW $99 SAVE $20**
3U HB5130 **WAS $139 NOW $119 SAVE $20**

FROM **$149**

SAVE UP TO $50

Fixed frame clear tempered glass door
6U HB5170 **WAS $179 NOW $149 SAVE $30**
12U HB5174 **WAS $239 NOW $189 SAVE $50**

FROM **$219**

SAVE $50

Swing frame clear tempered glass door
6U HB5180 **WAS $269 NOW $219**
12U HB5182 **WAS $349 NOW $299**

Need accessories for your rack?

GET 30% OFF

on shelves, cable support, cabinet panels,etc.

To order: phone 1800 022 888 or visit www.jaycar.com.au

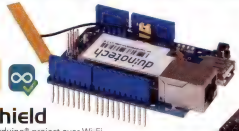
your destination for
the latest maker technology

We love to help you make things! Get started, or add to your collection of Arduino and Raspberry Pi compatible hardware, and build something new!

ARDUINO COMPATIBLE
This icon indicates that the product will work in your Arduino based project.

RASPBERRY PI COMPATIBLE
This icon indicates that the product will work in your Raspberry Pi project.

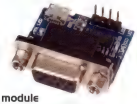
NOW
$59.95
SAVE $10



Yun wi-fi shield
Program and operate your Arduino® project over Wi-Fi and allow it to access the Internet. Contains a tiny Linux computer with Wi-Fi, ethernet & USB. XC4388 **WAS $69.95**

ESP-13 wi-fi shield
Uses the powerful ESP8266 IC and has an 80MHz processor. An excellent way to get into the Internet of Things (IoT). XC4614

ONLY
$9.95



RS-232 to TTL UART converter module
Connect a legacy device (or computer) to your existing Arduino® board. Providing a full RS-232 port, this shield allows you to directly communicate with a huge variety of serial peripherals. XC3724

Ethernet expansion module
A network shield that will allow you to set your Arduino® up as web server, control your project over your network or even allow your Arduino® to connect to the world wide web. XC4412

ONLY
$39.95

USB host expansion board
Brings the ubiquitous USB Host connectivity to your Arduino® project. Supports Google Android™ ADK allowing connections to Smartphones and Tablets. XC4456

ONLY
$79.95

Mastering microcontrollers helped by Arduino®
In this book theory is put into practice on an Arduino® board using the Arduino® programming environment.
- Softcover
- 380 pages

BM7144

ONLY
$69.95

C programming with Arduino®
Learn this standard language to program microcontrollers.
- Soft cover
- 343 pages

BT1388

IR / RF components

ONLY
$9.95

2.4GHz wireless transceiver module
Based on the NRF24L01 transceiver IC, this module allows communication on the license free ISM band. Supports on-air data rates of up to 2Mbps. XC4508

ONLY
$19.95

RF transceiver module
Adds a versatile 433MHz radio to your Arduino® project allowing two-way wireless communication between Arduinos. Includes antenna.
- 1.9-3.6VDC operating voltage
- Controlled via SPI

XC4522

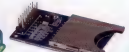
ONLY
$9.95

IR remote control for Arduino®
Add IR remote control to your next Arduino® project. Compact design with 21 buttons including numbers and channel controls. XC3718

data storage

ONLY
$9.95

Micro SD card shield for Wi-Fi mini
Add gigabytes of storage to your Wi-Fi Mini Main Board with this tiny shield and a microSD card. Allows you to use cheap microSD cards with the easy-to-use Arduino® SD library. XC3852



ONLY
$9.95

SD card interface module
Features 5V and 3.3V power inputs and resistors to allow safe on either IO voltage. Works with inbuilt libraries. XC4386

ONLY
$19.95

Data logging shield
Save your data to an SD card (not included), and use the inbuilt battery backed clock module to timestamp your readings. Uses a 3.3V converter to avoid damaging your SD card. XC4536

kit back catalogue

We maintain in our central distribution warehouse an extensive range of discontinued Electronic Project Kits. Place your order online for the Kit Back Catalogue. On our website each of these kits has a full description and, where available, a link to the original article on the Kit.
www.jaycar.com.au/kitbackcatalogue

CLICK & COLLECT Buy online & collect in store
zip own it now, pay later

your destination for

the best project ideas

project: GPS world clock

While most phones have the ability to display the local time throughout the world, you may not always have access to an internet connection. With our World Clock kit, all you need is a GPS signal to display time, date and location on an LCD screen.

SKILLS: Intermediate
TOOLS: Soldering iron, drill & file

See step-by-step instructions at www.jaycar.com.au/gps-world-clock

1 × DuinoTECH Mega Board	XC4420	**$49.95**
1 × GPS Receiver Module	XC3712	**$49.95**
1 × 128x64 Dot Matrix LCD Display Module	XC4617	**$29.95**
1 × Rotary Encoder with Pushbutton	SR1230	**$9.95**
1 × 150mm Plug to Socket Jumper Leads - 40pcs	WC6028	**$5.95**
1 × Jiffy Box - Black - 158 × 95 × 53mm	HB6011	**$4.45**
1 × 15mm × 3mm Steel Screws - Pk.25	HP0406	**$3.50**
1 × 3mm Steel Nuts - Pk.25	HP0425	**$2.95**
3 × 3mm Nylon Washers - Pk.10	HP0148	**$2.50ea.**
1 × 100nF 50VDC Capacitors - Pk2	RC5360	**32c**
PLUS your choice of knob		

NERD PERKS BUNDLE DEAL

$94.95

SAVE 40%

KIT VALUED AT $164.47

See other projects at www.jaycar.com.au/arduino

security essentials

FROM **$4.95**

Flush mount reed switch & magnet sets
Mounted into the door frame or window frame and wired into your system.
For Timber Frame LA5075 **$4.95**
For Metal Frame LA5076 **$5.95**

ONLY **$4.95** ea.

2.1mm DC connectors
Comes with screw terminals.
Plug PA3711
Socket PA3713

ONLY **$5.95**

Security alarm reed switch - double throw
Both types of contacts on the one unit: Normally Open (N.O.) and Normally Closed (N.C.) per pair.
LA5070

ONLY **$9.95**

BNC Plug to BNC plug
RG- 59U coaxial lead. 1.5m long. WV7300

ONLY **$19.95**

CCTV video & power cable
Combined power and video.18m. BNC terminated. WQ7279

FROM **$21.95**

Alarm cables
30m. Sold per roll.
4 Core WB1591 **$21.95**
6 Core ACA Approved WB1596 **$44.95**

project essentials

ONLY **$4.50**

Arduino® stackable header
Build a stackable shield, or make your current shield stackable. Includes:
1 × 10-pin, 2 × 8-pin, 1 × 6-pin, 1 × 2x3-pin (for ICSP). HM3208

ONLY **$14.95**

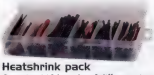
ISP programmer for AVR
Unbrick, install or update your Arduino®-compatible boards. XC4627

ONLY **$5.50** ea.

Hook-up cables
Quality 1.3 × 0.12 tinned hook-up wire on plastic spools. 8 different colours available. 25 metre roll. WH3000-WH3007

See how to use the XC4627 with Arduino® boards and ZZ8727 on our project page: **www.jaycar.com.au/isp-programming**

ONLY **$19.95**



Heatshrink pack
Contains 160 lengths of different sizes in a handy storage case. WH5524

JUST **$12.95**

ATMega 328P IC
Build your very own customised Arduino® compatible projects. Comes with Uno bootloader and 16MHz crystal oscillator. ZZ8727

your destination for
in-home technology solutions

NOW
$149
SAVE $20

2 bay USB 3.0 SATA HDD RAID enclosure
Have your files backed up. Tool less & driverless. Supports 2.5" and 3.5" HDD.
- Raid 0, Raid 1, JBOD, Spanning
- Up to 5Gbps transfre rate
- Capacity: 8TB Per Bay
- 215(L) × 135(W) × 114(H)mm

XC4688 **WAS $169**

NOW
$34.95
SAVE $10

USB 2.0 external 3.5" HDD case
Accommodates a 3.5" SATA drive up to 3TB in storage capacity. Lightweight aluminium case for increased portability.
- USB 2.0 transfer rate up to 480Mbps.
- 183(D) × 117(W) × 31(H)mm

XC4669 **WAS $44.95**

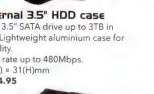
ONLY
$99.95

2.5" 1TB notebook HDD
Ideal for laptops, network attached stored devices, game consoles or media players. Uses the superior 500GB per platter technology.
69(W) × 9(H) × 100 (D)mm. XC5680
ALSO AVAILABLE:
3.5" 2TB Surveillance HDD XC5682 **$159**

FROM
$44.95
XC4687

USB 3.0 SATA HDD docking stations
Connect 2.5" or 3.5" SATA hard drives to your computer. Plug and play technology. USB 3.0 for fast data transfer.
- Transfer Rate: 430Mbps
- HDD capacity: 8TB

Single XC4687 **$44.95**
Dual XC4689 **$59.95**



NOW
$39.95
SAVE $5

SATA/IDE to USB 2.0 HDD adaptor
Backup or transfer large amounts of data between drives. Supports up to 3 hard drives simultaneously.
XC4150 **WAS $44.95**

ONLY
$19.95

IDE to SATA HDD upgrade panel
A simple method for upgrading IDE drives.
- 105(W) × 259(H) × 62(D)mm

XC4970

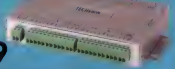
See our keyfob, wafer card & lanyard card style tags available in-store or online:
www.jaycar.com.au

- WATERPROOF
- BACKLIT KEYPAD
- LED INDICATOR Green/Yellow/Red
- BUILT-IN BUZZER

NOW
$109
SAVE $20

Digital keypad with RFID access control
Suitable for areas requiring stricter access control such as warehouse, bank, etc. Housed in a sturdy IP65 vandal proof zinc alloy case. Support up to 2,000 users. Indoor/outdoor mounting.
- 82(W) × 128(H) × 28(D)mm

LA5353 **WAS $129**



JUST
$299

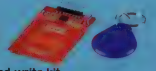
4 door RFID access controller
Control up to 4 doors, 4 readers and 4 exit buttons. Perfect for large or small businesses with up to 20,000 users and permanent entry logging up to 100,000 times.12VDC.
- 201(L) × 125(W) × 32(H)mm

LA5359

ONLY
$89.95

RFID access card reader
A robust mini access card reader which can be used as standalone or slave with an Wiegand 26 input access control system. Reads EM & HID RFID cards. Large capacity for up to 10,000 users. 12VDC, IP65 rated.
- 48(W) × 103(H) × 23(D)mm

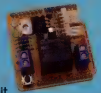
LA5351



JUST
$19.95

RFID read and write kit
Allows you to both read and write MiFare-Type RFID cards. Includes one credit-card style tag and one key-fob style tag.
- 3.3VDC operating voltage

XC4506



JUST
$9.95

RFID lock shield kit
Allows your Arduino® to control a door lock using an electric strike plate and one commonly available RFID module. *Limited stock.
XC4215

telephone & network connectors

ONLY
$4.95

RJ45 inline joiner
RJ45 8P/8C socket to socket. Wired straight through. YT6080

ONLY
$5.95

US modular inline coupler - 6P/4C
Connects two US plugs together. RJ12. Socket to Socket. YT6060

ONLY
$5.95

Modular double adaptor - RJ12
Connect two telephones to the one socket. 6P/4C. YT6056

ONLY
$7.95

Wall phone bracket
RJ12 6P/4C.
ACMA approved. YT6062

FROM
$9.95

Extension cables
RJ12 6P/6C. Plug to plug. 1 to 15m lengths available. YT6033 - YT6038

make your home connected:

Did you know that you can make your own smart home controller to control your garage door, air conditioner, room lights, or monitor your garden soil moisture using the low cost yet very powerful Wi-Fi enabled ESP32 or ESP8266 development boards! Why not integrate your smart home devices with free cloud services from Google Home®, Amazon Alexa® or IFTTT® to Make Your Home Connected.
What is special about a Connected Home? ... Well imagine when you turn on the TV after 6:00pm, your smart connected home knows to also turn down the room lights, and if the room temperature is below 15°C, to also turn on the aircon to set the temperature to a comfortable 23°C, just the way you like it. This is only one scenario of the many possibilities and life comforts in a connected home.

ONLY **$24.95**

Wi-fi mini ESP8266 main board

Offers a massive 4MB program memory, and an 80MHz 32bit processor. Built in Wi-Fi 802.11 n/b/g, I2C, Serial UART, 11 GPIO, and an analogue input. Easy to program using the popular Arduino IDE. The perfect platform for your DIY connected smart home devices. XC3802

ONLY **$39.95**

ESP32 main board

with wi-fi and Bluetooth®

Connect to anything and everything: Wi-Fi and Bluetooth with the ESP32 dual core 32bit microcontroller. Offering 512kB of RAM, 4MB of flash memory, 12bit ADC, 8 bit DAC, I2S, I2C, touch sensor and SPI. Easy to program using the popular Arduino IDE. This is the next step in advanced DIY connected home automation. XC3800

JUST **$4.95**

Infrared transmitter module

Connect the IR Transmitter to your ESP8266 or ESP32 to control IR appliances such as your TV, stereo system, or aircon, etc., Set-up your device to talk to Alexa or Google Home and you can control your appliances via voice control or over the Internet. XC4426

ONLY **$13.95**

433MHz wireless transmitter

433MHz radio control is widely used in garage door, gates, and other mains appliance control. Connect this module to an ESP8266 or ESP32 development board and you can make cleaver 433MHz controllers. Set-up your device to talk to Alexa or Google Home and you can control your home appliances via voice control or over the Internet. ZW3100

FROM **$49.95**

Remote control relay boards

Use the 433MHz transmitter together with an ESP32 or ESP8266 microcontroller to control the relay module. Open and close your garage door, turn on your water pump, or anything else in your connected home using this versatile and easy to build solution.
2 Channel LR8855 **$49.95**
4 Channel LR8857 **$69.95**

infrared

ONLY **$39.95**

Wi-fi smart remote

Control almost any appliance that use IR remote control. It replaces the appliance's remote control and allows you to control your appliance via a Wi-Fi smart App. Integrate the Wi-Fi Smart remote with your connected home and you can do much more. AR1974

lighting

FROM **$49.95**

Smart wi-fi LED bulbs

Connect to your Wi-Fi and allow you to control the light, on/off and dimmable from the comfort of your chair or bed, using a smartphone APP, or integrate it into your connected home and ask Alexa or Google Home to turn your lights on or off.
Dimmable 600 Lumen YN8452 **$49.95**
Tuneable White YN8450 **$69.95**
Colour Change YN8448 **$99.95**

access control

ONLY **$249**

Wi-Fi RFID access keypad

Forgot your keys no problem! With this smart access controller, you can remotely open your door with your smartphone. It can be used as a standalone access card reader or in a connected home, it can be controlled by an external access controller. LA5358

your destination for

your workbench essentials

$74.95
SAVE $10

$12.95

$59.95
SAVE $20

$129
SAVE $30

$29.95

$54.95
SAVE $15

1. Uninterruptible power supply with computer interface
- 300W 600VA
- Surge protection
- 7Ah battery
- USB port
- Mains powered

MP5224 **WAS $159**

2. USB charging station - 5 port
- Boasts a maximum power output of 2.4A per port
- Includes 6 dividers and 12VDC, 4A power supply
- 165(L) × 120(W) × 62(H)mm

WC7766 **WAS $69.95**

3. Dual PC monitor desk bracket
- VESA compliant
- Fits most 13" to 27" flat-screen displays
- Metal frame with scratch-resistant, powder-coat finish

CW2875 **WAS $79.95**

4. 2 in 1 network cable tester and DMM
- Measure AC & DC voltages up to 600V.
- CATIII, 2000 count
- AC/DC current up to 200mA
- Resistance measurement

XC5078 **WAS $84.95**

5. Magnetic project work mat
- Holds small metal screws, nuts and bolts
- 254(L) × 203(W)mm

TH1867

6. Gaming console tool kit
- Nintendo & X-Box security bits
- X-Box opening tool
- Stainless tweezers
- Ratchet handle and adaptor

TD2109

handy tools for network installers

ONLY
$8.95

Cat-5 punch-down tool
Strip wire up to 5-6mm, and doubles as a punch-down tool for 110/88-type terminals with blade. TH1738

NOW
$79.95
SAVE $20

Network cable tracer
Easily trace cables even when cables are in a bundle or hidden in punchdown blocks or wall plates. Also checks telephone line polarity and status i.e ring/busy/idle.
- Single/multi tone signal

XC5083 **WAS $99.95**

NOW
$14.95
SAVE $5

Handy magnet strip
Attached to walls, tables or other surfaces to hold tools, brushes, scissors, etc. 7 piece magnet, each holds up to 1kg.
- 750(L) × 25(W)mm

*Tools not included

LM1624 **WAS $19.95**

NOW
$39.95
SAVE $10

4P/6P/8P/10P Modular Crimp Tool
Cut, strip, and crimp flat telephone or CatSE type cable. TH1936
WAS $49.95

FROM
$6.95

Plastic fan guards
Foam filter prevents dust particles entering the fan.
- Made from plastic rated to UL 94V-0

60mm YX2550 **$6.95**
80mm YX2552 **$6.95**
120mm YX2554 **$7.95**

YX2580

- LONG LIFE
- LOW NOISE

FROM
$24.95

MagLev bearing case fans
Nanoflux bearings. 100,000hrs operational life at 40°C (even longer at 25°C). Dust and waterproof to IP54. Flylead with 3 pin molex. 12VDC.
80mm YX2580 **$24.95**
90mm YX2582 **$29.95**
120mm YX2584 **$34.95**

YX2517

FROM
$36.95

Ball bearing fans
240VAC. Solder lug connection
80mm Flylead YX2508 **$36.95**
120mm Solder Lugs YX2517 **$36.95**
150mm Flylead YX2520 **$84.95**

NOW
$59.95
SAVE $10

4P/6P/8P modular crimp tool with network/POE tester
Combination crimper tool and ± cable tester in one unit. Tests both UTP and STP cable.
- Single and multi-wired cable crimping
- Detachable cable tester

TH1939 **WAS $69.95**

FROM
70¢/m

WB1620

Telephone cables
Flat cable. Ivory colour.
- ACA approved.
- Sold per metre or 100m roll

2 Pair (4-Wire) WB1620 **70c/m**
3 Pair (6-Wire) WB1622 **90c/m**

FROM
$1.90/m

WB1575

Computer cables
All are shielded to stop RFI.
- Sold per metre or 100m roll

6-Way WB1575 **$1.90/m**
9-Way WB1578 **$2.20/m**

ONLY
$1.45/m

WB2020

Cat 5 solid network cables
ACA approved. High quality.
- Sold per metre or 100m roll

8-Core Stranded WB2020
Solid Core WB2022

CLICK & COLLECT Buy online & collect in store

zip own it now, pay later

nerd perks club members
exclusive club offers

WE HAVE SPECIAL OFFERS FOR OUR CLUB MEMBERS EVERY MONTH. LOOK OUT FOR THESE DEALS IN-STORE!

Not a member? Visit www.jaycar.com.au/nerdperks

ONLY **$79.95**

Door entry alert

Commercial grade, entry warning system!
LA5193
Counter
LA5197 **REG $49.95**
Door Buzzer
LA5188 **REG $34.95**
*Applies to LA5197 & LA5188 with purchase of LA5193

NERD PERKS SAVE **30%** OFF ACCESSORIES*

ONLY **$99**

NERD PERKS SAVE **20%**

UHF premium antenna kit

Includes stainless spring & elevated feed base, 6.5db & 3dB factory tuned antennas, 5m RG58 lead with FME socket and PL259 adaptor. DC3071 **REG $129**

NOW **$179**

NERD PERKS SAVE **$50**

10 Port PoE network switch

Connects up to 8 Power Over Ethernet (PoE) IP cameras, routers & access points.
YN8049 **REG $229**

NERD PERKS SAVE **20%**

Weatherproof buzzer
Heavy duty, 6-14VDC, 26mm dia.
AB3466 **REG $16.95 CLUB $12.95**

NERD PERKS SAVE **35%**

RJ45 modular plugs
For stranded and solid CAT6 cable. Pk10.
PP1447 **REG $13.95 CLUB $8.95**

NERD PERKS SAVE **25%**

200gm duratech solder
60% Tin / 40% Lead. Resin cored. 2 sizes available. 1.00mm & 0.71mm.
NS3010/NS3005
REG $15.95ea CLUB $11.95ea

NERD PERKS SAVE **20%**

Multi-function circuit tester
LED indicator. 12/24V.
QM1494 **REG $64.95 CLUB $49.95**

NERD PERKS SAVE **20%**

Speaker cable - 30m roll
Extra heavy duty Fig 8.
WB1713 **REG $74.95 CLUB $59.95**

NERD PERKS SAVE **25%**

Universal tablet headrest mount
Padded clamps. 360° rotating ball-joint.
HS9033 **REG $19.95 CLUB $14.95**

NERD PERKS SAVE **25%**

Long range infrared spotlight
50m viewing range. Weatherproof.
QC3654 **REG $79.95 CLUB $59.95**

NERD PERKS SAVE **35%**

3AG fuse pack
500mA - 10A. 40 fuses.
SF2240 **REG $12.95 CLUB $7.95**

NERD PERKS SAVE **30%**

Professional cat IV multimeter probes
High grade. 120mm long.
WT5338 **REG $21.95 CLUB $14.95**

NERD PERKS SAVE **25%**

24V EI core transformer
24V, 72VA, 3A rated. 200mm flylead connection.
MM2012 **REG $27.95 CLUB $19.95**

NERD PERKS SAVE **20%**

USB port to RS-485/422 Converter
Up to 480Mbps data transmission.
XC4136 **REG $49.95 CLUB $ 39.95**

NERD PERKS SAVE **50%**

IN4007 IA 1000V diode
Pack of 100.
ZR1008 **REG $12.95 CLUB $ 6.45**

a better club is coming. keep being rewarded!

Check your email & contact details are correct In-store or online now. Don't miss out!

GET 10% OFF*
mains laptop power supplies

*See T&C's for details

what's new

FROM ONLY
$49.95

- **MORE POWERFUL**
  Deliver twice as much current under load
- **RECHARGE FASTER**
  Accept a higher charge current
- **MORE PORTABLE**
  Weigh half as much
- **SAFER**
  Do not produce explosive hydrogen gas
- **LONGER LIFE**

The next generation in power is here!

Lithium Iron Phosphate (LiFePO4) batteries are the latest in battery technology. Featuring up to 10 times the battery cycle life with only half the weight of its lead-acid equivalent. More reliable too with faster recharging and reduced number of charges.

6.4V 4.5Ah SB2200 **$49.95**
12.8V 7.5Ah SB2201 **$129**
12.8V 18Ah SB2202 **$249**
12.8V 100Ah SB2203 **$999**

ONLY
$199

20A MPPT solar charge controller for lithium or SLA batteries

Uses Maximum Power Point Tracking (MPPT) for maximum efficiency and charge rate. Supports sealed, gel or flooded lead acid and Lithium batteries. 3-stage intelligent charging. MP3741

JUST
$14.95

Miniature 12/24V 3A PWM solar charge controller

Uses Pulse Width Modulation (PWM) to manage battery charging from a connected solar panel. 3 stage charging. Light & timer control. LED indicator. MP3762

FROM
$8.95
SL3530

Automatic LED night lights with sensor

Automatically switches on and off based on ambient light. Mains powered. Plug and play.
• SAA approved
Night Light SL3530 **$8.95**
Hallway Light SL3531 **$9.95**

ONLY
$49.95

10A double gpo power point with in-built rcd

Designed to be a direct replacement to your standard GPO fittings, combining two standard 240AC 10A mains (GPO) outlets with a built-in RCD to provide protection against electrical shock. LED indicators. PS4048

ONLY
$69.95

Wireless infrared remote control extender

Allows you to use your remote control on devices up to 50m away! Plug and play operation. USB powered. Includes 1x transmitter, 1x receiver and 2x mains power adaptors. AR1866

ONLY
$79.95

Toslink & coax audio cat5e/6 extender with IR

Perfect for running ultra-long digital audio connections up to 200m with no loss in quality! Includes 2-way infrared emitter, infrared receiver and mains power adaptor. AC1733

JUST
$34.95

3-Way optical toslink splitter

Distribute your digital audio connection to multiple sources such as sound bars, headphones or your home theatre system. USB powered. AC1590

ONLY
$249
Bluetooth®

12" Rechargeable PA speaker with Bluetooth® technology

Play your music from a Bluetooth® source, USB flash drive, microSD card or auxiliary input. USB/microSD playback & recording. Extendable trolley handle & wheels. CS2497

TERMS AND CONDITIONS: REWARDS / NERD PERKS CARD HOLDERS FREE GIFT, % SAVING DEALS, DOUBLE POINTS & MEMBERS OFFERS requires ACTIVE Jaycar Rewards / Nerd Perks Card membership at time of purchase. Refer to website for Rewards/ Nerd Perks Card T&Cs. PAGE 1: 30% OFF Rack Mount Accessories applies to Jaycar 232A. Enclosures & Panel Hardware - Metal Rack Enclosures. PAGE 3: Nerd Perks Card Holders receive a special price of $94.95 for GPS World Clock Project Kit when purchased as bundle [1 × MP3290 + 1 × XC4617 + 1 × XC4420 + 1 × XC3712 + 1 × WC6028 + 1 × HP0406 + 1 × HP0425 + 2 × HP0148 + 1 × HB4011 + 1 × RC5300]. PAGE 7: Nerd Perks Card holders receive 30% OFF RRP on LA5197 Counter or LA5188 Door Buzzer with every purchased of LA5193 Door Entry Alert. Nerd Perks Card Holders receives 10% OFF Mains Laptop Power Supplies. Applies to Jaycar 70TO Connectivity - Computer Power Products excluding UPS (MP5205, MP5207 & MP5224).

NEW STORE
auburn
233-239 Parramatta Rd, NSW 2142
PH: 02 9648 1360

For your nearest store & opening hours:

1800 022 888
www.jaycar.com.au

100 stores & over
140 stockists nationwide

jaycar

Head Office
320 Victoria Road,
Rydalmere NSW 2116
Ph: (02) 8832 3100
Fax: (02) 8832 3169

Online Orders
www.jaycar.com.au
techstore@jaycar.com.au

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock. Savings off Original RRP. Prices and special offers are valid from catalogue sale 24.1.19 - 23.2.19.

PRODUCT SHOWCASE

New "WT" Soldering Station range from Weller

The powerful new generation Weller WT101AU soldering station is claimed to be innovative, easy to use and highly cost-effective, combining the low cost of a passive soldering system with the design and ergonomics of an active one.

With the new lightweight and thin 90W soldering iron, Weller is presenting the world's first active soldering system with replaceable, passive, high performance soldering tips. It features a soft rubber grip and thin silicone cable.

Multiple stations can be stacked on top of one another saving vital desk space. The display boasts a new inclined design offering a more natural viewing angle and features clearly arranged graphics which make it possible to understand setting parameters at a glance.

The control panel on the front is distinctive and offers an uncluttered and particularly clear design. All of the important operating elements are placed on the front. The menu button ensures instant access allowing users to navigate through the menu structure easily.

Weller soldering equipment is distributed by the Apex Tool Group.

Contact:
Apex Tool Group Australia Pty Ltd
Suite 202 4-10 Bridge St, Pymble NSW 2073
Tel: (02) 9425 6600
Web: apextoolgroup.com.au

Mouser Electronics Now Shipping New Arduino Uno WiFi Rev 2

Mouser Electronics, Inc. is now shipping the highly anticipated Uno WiFi Rev 2 from Arduino. The first AVR-based, natively-enabled Internet of Things (IoT) board from Arduino, the Uno WiFi Rev 2 board integrates an 8-bit microcontroller, WiFi module, sensors, and hardware-based security in the familiar Uno Rev 3 form factor. The new board addresses the wireless connectivity and low power demands of the growing IoT market.

The Arduino Uno WiFi Rev 2 is based on the new Microchip Technology ATmega4809 megaAVR microcontroller. The ATmega4809 offers Core Independent Peripherals (CIPs) and an integrated high-speed analog-to-digital converter (ADC) with voltage reference for faster conversion of analog signals. The microcontroller also provides more memory than on previous Uno boards, boasting 48 kBytes of flash and 6 kBytes of RAM, plus three UARTs to enable communication with more than one RF module.

It includes a u-blox NINA-W13 module with integrated TCP/IP protocol stack to provide 802.11b/g/n Wi-Fi connectivity enabling access to a Wi-Fi network or for use as an access point. The board also features support for over-the-air (OTA) programming for transfer of Arduino sketches or Wi-Fi firmware. Wireless security is provided by a Microchip ECC608 CryptoAuthentication IC, which combines hardware-based key storage with hardware cryptographic accelerators to implement authentication and encryption protocols. Other features include onboard debugging, inertial measurement unit (IMU) with 3-axis accelerometer and 3-axis gyroscope, 14 digital input/output pins (five PWM outputs) and six analog inputs.

Contact:
Mouser Electronics
Web: www.mouser.com/arduino-uno-wifi-rev2

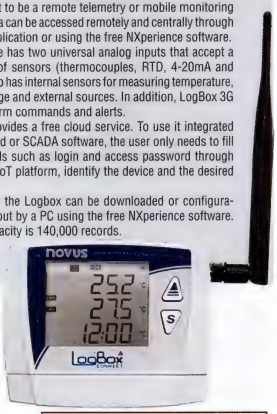
Novus LogBox 3G IoT data logger

The new Novus LogBox 3G is an Internet of Things device with an integrated data logger and 3G mobile connectivity. This allows it to be a remote telemetry or mobile monitoring solution. Data can be accessed remotely and centrally through a SCADA application or using the free NXperience software.

The device has two universal analog inputs that accept a wide range of sensors (thermocouples, RTD, 4-20mA and 0-10V). It also has internal sensors for measuring temperature, battery voltage and external sources. In addition, LogBox 3G has SMS alarm commands and alerts.

Novus provides a free cloud service. To use it integrated with the cloud or SCADA software, the user only needs to fill in a few fields such as login and access password through the NOVUS IoT platform, identify the device and the desired channel.

Data from the Logbox can be downloaded or configuration carried out by a PC using the free NXperience software. Memory capacity is 140,000 records.



Contact:
Ocean Controls
44 Frankston Gdns Dve, Carrum Downs Vic 3201
Tel: (03) 9708 3290
Website: oceancontrols.com.au

SERVICEMAN'S LOG

(What) were the designers thinking?

Dave Thompson

One problem with being an engineer, a serviceman, or similar is that whenever we see something mechanical or electrical, we immediately (and mostly subconsciously) assess it for a range of criteria, such as what it is made of and the methods used to manufacture it. Or, in my case (especially in my younger, more inquisitive days), how one could take it apart. Basically, we can't help but be analytical.

Items Covered This Month

- Learning a painful lesson
- HP 3585 spectrum analyser repair

Dave Thompson runs PC Anytime in Christchurch, NZ.

Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz

Let's face it – everything we use, buy or make has a design element to it, and supposedly some theory sits behind that design. However, I often find myself quietly cursing the stupidity of some of these designs because it appears that no actual thought processes have gone into them.

This phenomenon is by no means modern; engineers have been bemoaning poor design for as long as there have been people making things.

It might seem more prevalent these days because of the number of YouTube channels dedicated to pulling apart everything from tools and machinery to appliances and cars, often for laughs. But they always seem to be asking the age-old question: what was the designer thinking?

I can reel off several examples for you. I grew up with older British-made cars and some of the decisions made during the manufacture of those vehicles begs the same question.

To get the engine out of a Morris, Austin, MG or Wolseley 1100/1300 for example, you either have to have double-jointed hands the size of a small child, cut an access hole in the passenger floor pan, or have an impossible-to-source specially-made spanner.

I had the motor in and out of my 1300 so many times we cut a hole in the floor (replacing it with a suitable access cover) and used a special spanner Dad made after seeing one at a garage in town.

And take the original Mini; iconic though it is, one gets the distinct impression that they designed and built the car and then discovered they'd left nowhere for the battery, so it went in the boot. There are many other examples and while I know these cars were built down to a price, making life more difficult for the poor sod who inevitably has to work on it is just not cricket.

Editor's note: making fun of poor British car design is like shooting fish in a barrel. Who hasn't heard of Lucas Electrics, AKA the Prince of Darkness? They were truly innovative: they invented

TO GET THE ENGINE OUT OF A MORRIS 1100 YOU EITHER HAVE TO HAVE DOUBLE JOINTED HANDS THE SIZE OF A CHILD OR...

the intermittent wiper, the first self-dipping high-beam and they also produced a very potent anti-theft device: their ignition systems. It's difficult to steal a car that won't start!

A design dud in the kitchen

A while ago, we purchased a sandwich maker; one of those clam-shell types that closes and bisects the sandwich while cooking it. In my opinion, this device has several design problems.

Firstly, the top plastic cover protrudes out over the bottom section at the rear of the maker, ostensibly to cover the hot hinges and keep them away from wayward hands.

But the steam produced while cooking is very effectively trapped by this hollow, overhanging moulding. The steam then condenses and drips down onto the bench and power cable. We have to put a folded paper towel or similar beneath it, to avoid pools of greasy water forming under the back feet.

While this is no deal-breaker, it clearly isn't a good design. And that isn't the only problem, either. The more significant failing is the fact that no matter what brand of bread we buy, none of the slices fit correctly.

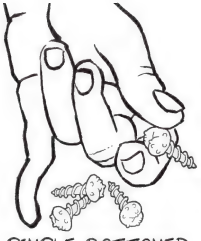
The bread slices either fit entirely inside the cooking cavity and don't make contact with the edges, or they end up with one edge sticking out the sides. *(Editor's note: perhaps you are using metric bread, and it was designed for imperial? Try using a British Standard Loaf and see if that fits.)*

While the smaller slice might seem the way to go, fillings (cheeses in particular) bleed copiously from any seam that isn't clamped and sealed by the elements and then proceed to leak out all over the rest of the machine and the benchtop.

This leads us to another design flaw: the gaps between the elements and the case mouldings. From the first sandwich we made, these cavities fill up with crumbs, cheese, water and anything else that might be cooked in the appliance. After just a few months of weekend-lunch use, this sandwich maker was so filthy and impossible to clean properly that my wife refused to use it anymore.

Being the gentleman serviceman, I took it to the workshop and stripped it down to clean it out, and what a lovely job that was!

It is generally pretty easy to take



PIMPLE-BOTTOMED TORX-STYLE SCREWS

apart, except for the vain attempt by the manufacturer to prevent me undoing four, pimple-bottomed Torx-style "safety screws".

But I did have to cut the connector-secured power cables off to free the bottom plastic case shell, as the power lead clamps to it with flying wires connecting to the elements through a small hole in the case.

The reason I went that far is because the bottom half was almost completely covered with both greasy and rock-hard melted cheese and breadcrumbs.

I had to chip some of it off with a screwdriver. I used my heat gun to soften the baked-on gunk on the outside of the case because it couldn't be removed without otherwise damaging the shiny plastic finish.

I would have expected this type of mess after a year's worth of use by a family of five, but it seems a bit excessive for a few months use by two of us.

Of course, we could use a smaller quantity of ingredients, but where's the delight in an empty toasted sandwich?

A quick visit to some big-box stores with a pocket tape-measure confirmed my suspicion that all similar sandwich makers have the same size cooking cavities as ours, or very close to it. Has no sandwich-maker designer ever purchased a loaf of bread at the supermarket?

Perhaps there is a theoretical standard slice size, but if so, not many bakers adhere to it. If I designed a sandwich maker, I'd make it so that the majority of everyday bread slices fitted it properly.

WE COULD USE A SMALLER QUANTITY OF INGREDIENTS, BUT WHERE'S THE DELIGHT...?

Ah, the bad old days

A more severe example of designer negligence harks back to my days as an aircraft engineer. Actually, I was technically still an apprentice at the time, in my final year and just before my final trade exams.

For those not familiar with wide-bodied aircraft, at least back in those days, most of the major electronic components are kept in a special area called the E&E (Electronic and Equipment) bay.

Much of an aircraft's radios, controllers, computers and various other components are packed into this space, mounted in special racks and cabled in with vast looms of wires strung from the farthest reaches of the plane.

This room is accessible via a hatch beneath the aircraft (sometimes from inside as well) and it varies in size depending on the aircraft. The E&E bay on a 737 is a lot smaller than that on an A380. On some planes, I'd need a step to boost me up enough to climb in, while taller guys could often work standing on the ground.

On the particular aircraft I was working on then, an ageing Boeing 727, one of three then-used as transports by our Air Force (nothing but the oldest and cheapest crates for our boys!), the bay required me to climb a special ladder to access it. As I was of a smaller and skinnier physical size back then, I got all the jobs the bigger guys opted out of.

Being an apprentice also had a lot to do with this, and apprentices usually got fun jobs like cleaning bird remains from the engines of aircraft that had suffered bird strikes.

Bird strikes are rare (thank goodness!), but when they happened, the task of cleaning the rear section of the engine would be passed down the chain of command until it hit the bottom – an apprentice.

As one of the guys said at the time, "manure rolls downhill"; although those are not the exact words that he used.

You'd think that a seagull going through all the turbines and vanes spinning at thousands of RPM inside those big jet engines would essentially be vaporised. This is not the case, and it is a particularly unpleasant task to kneel in puddles of aviation fuel in a confined and grimy metal tube scraping crispy bird remains from the sides of the engine. It put me off chicken for years.

Thankfully, as I moved up the pecking order (hah!), that job became a younger apprentice's problem.

Learning a painful lesson for someone else

One job I did do a lot, just because I was one of the smallest qualified guys, was inspecting, cleaning and repairing wiring looms inside the wing-tanks on whatever plane needed it.

If you think there isn't enough room in the wing of a plane for a person to work, you are mostly right; it is a very tight and claustrophobic space, especially when decked out with all the lights and breathing gear and carrying special anti-static tools.

My foreman always swore that he'd cut a hole in the skin of the wing if I ever got stuck in there, but now I'm not so sure he'd have kept that promise!

But I digress; I had work to do in this 727's E&E bay, adding wires to an existing loom for some new component going in. This required me to contort myself into a flat position on my back while curling around sideways to get right in behind one of the racks so I could crimp and terminate the wiring into a Canon connector mounted on a frame there.

It was tight and taxing work and once again, because I was one of the smaller guys, I got assigned to do this type of thing a lot.

The problem wasn't getting into position, but getting out again when my arms were in behind the racks and my feet hanging out the hole in the floor; I didn't have a lot to push against to make my way out. I reached up to lever myself against the back of the rack and felt a sudden hard whack, as though someone had knocked my hand away with a bat.

When I pulled my hand in front of my face, the top 5mm of my right thumb was hanging by a thread, and there was blood everywhere. Yikes! I didn't know what I'd done at the time, and can't recall how I got out, but I do remember walking up to the guys in the workshop by the hangar floor holding my hand out and telling them I thought I might need the nurse!

It turns out that some bright spark in a design department somewhere had dreamed up a modification to keep some equipment cool in the bay and a 120mm steel-bladed cooling fan had been fitted to the rear of one of these racks on a previous maintenance visit. I didn't know it was there, and the powers-that-be saw no need for a safety cover for the fan because it was mounted "out of the way".

Now, modifications like this aren't just dreamed up by some bloke with a hangover one Monday morning and installed that afternoon.

This would have been thought out and put through rigorous checks and balances at the highest levels by the manufacturer, or one of their contractors. They would first see if it was required, then ensure it was implemented to the highest possible standards.

This process also involves updating the very comprehensive manuals that go with every aircraft; these huge books document every nut, bolt, panel, cable, washer, rivet, system, component and piece of equipment inside it, along with all the specifications, circuit diagrams and schematics of literally everything on board.

Not one of the dozens of people involved in this design process thought about installing a safety screen.

Any new addition to an aircraft, regardless of whether it is a plastic bung for the end of a seat frame or a whole new navigation system, is also rigorously tested – destructively and non-destructively – by the aircraft manufacturer and interested third-parties before getting anywhere near a plane.

It can take many months, if not years, before the information and parts are eventually available to the end-users for implementation. Something fell short here.

Inevitably, I had to take time off work and the injury also caused me to miss my final exams – which I had

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column? If so, why not send those stories in to us?

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

to sit later. I also had to play guitar at a friend's wedding that weekend and did so painfully, with the pick taped to my comically-large thumb bandage. My right thumb is still shorter than my left because the base doctor just tore the damaged bit off and threw it in the bin!

I recall it hurting, a lot, and it didn't help when several guys from the technical department came over and had a look around before interviewing me, claiming they never thought – and I quote – that "anyone would be stupid enough to stick their hand in it".

The only silver lining is that the fan was running in the direction that pushed my hand out, rather than simply ate it whole. A mesh screen was eventually fitted and I'll wager most other fans fitted after that had one too, regardless of where they were situated.

I (and others) couldn't believe this mod had made its way right through the testing and vetting process without someone realising that having a high-speed steel cooling fan unshrouded in a work environment might be a bit of a health and safety issue. I mean, we are talking about an industry that is typically extremely paranoid about every aspect of safety!

I'm guessing that the character sitting at a drawing board who originally dreamt this up, along with the people who subsequently signed off on it, have never had a pair of overalls on or wired a rack in an E&E bay. You just can't beat hands-on experience.

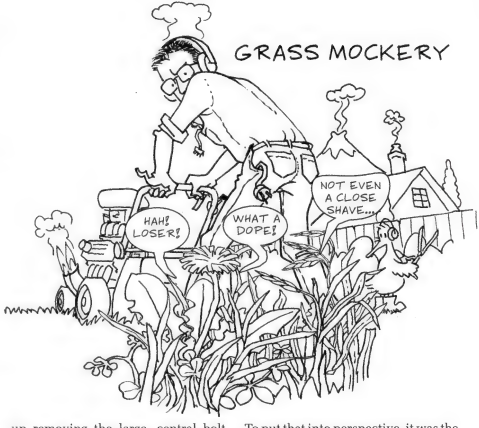
Even the grass is mocking me

And on another note, I recently purchased a new lawn mower, given it's the time of year when you can hear the grass growing. It is a well-known, dayglow yellow brand and I assumed they'd know a thing or two about making lawnmowers.

However, when I tried it, even set at the lowest blade position, the lawn was still looking uncut. I like a short lawn; not shaved earth, but preferably cut enough so I don't have to do it twice a week. All my old mowers could cut this short but this one goes no shorter than the industry standard of 25mm.

I contemplated modifying the level notches on the side, but even with the deck scraping on the ground, the cut was still far too long. The blade disc is just too high in the deck. I ended up removing the large, central bolt holding the blade disc on and added 10mm of washer shims to the top-hat style mounting plate before bolting it all back on.

It now it cuts perfectly, but it begs the question; did the guy who designed this mower ever mow an actual lawn with it?



HP 3585 spectrum analyser repair

A. L. S., of Turramurra, NSW, has had one thing after another go wrong with his 40-year-old Hewlett-Packard spectrum analyser. But he's obviously very attached to it since he keeps on fixing it each time. Here is what he had to do to keep it going over the last couple of years...

The HP 3585 Spectrum Analyser is a very versatile instrument, covering the frequency range of 20Hz to 40MHz with a 3Hz resolution, making it useful for both audio and RF applications. It also has a built-in tracking generator.

Unlike most spectrum analysers (which usually only tolerate tiny RF signals), its input capabilities are really good with a selectable input impedance of 50Ω, 75Ω or 1MΩ and with 42V peak handling, which is ideal for testing medium-power audio amplifiers.

I purchased this one locally for a few hundred dollars on eBay; that's quite a bargain when you consider that it was more than $30,000 brand new in 1978. To put that into perspective, it was the same price as a Mercedes Benz 450SL!

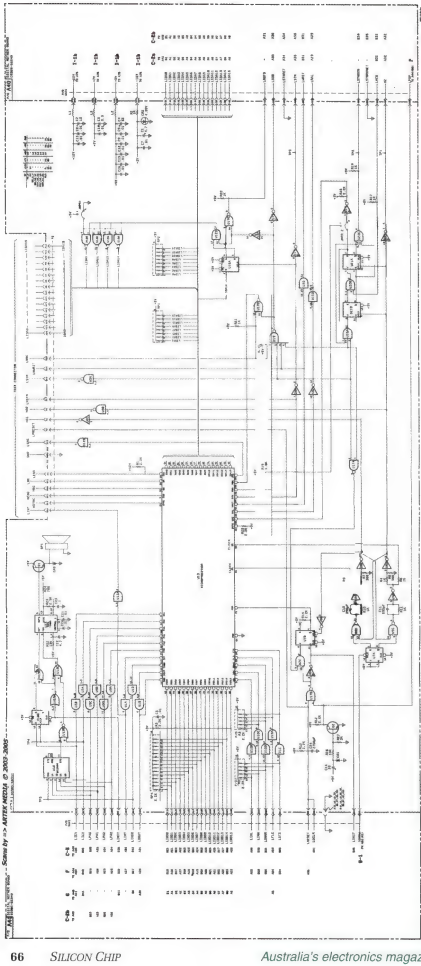
My unit had a number of faults that occurred over a two year period, so in that respect, it's probably about as reliable as an old Merc too.

First, some intermittent flashover started happening in the CRT EHT section, usually during periods of high humidity, causing the CRT to eventually fail altogether. I noticed that the LEDs on the front panel appeared to still be operating normally and a quick screen grab using a GPIB/USB connection proved that the instrument was still fully functional, apart from the lack of display.

Using the display (X & Y) BNC connections at the back of the instrument, I was able to obtain a very good working display on a 20MHz analog oscilloscope set to X/Y mode, as shown in the accompanying photo. This only works with an old-fashioned CRO though; most digital scopes are just not fast enough to do this!

I used this arrangement for some time while I waited for a surplus CRT and EHT supply to arrive which I had ordered from the internet. When they finally came, I first had to turn the instrument upside-down, which was difficult because it weighs 40kg!

I removed the HT supply box to take a closer look and to figure out how to change the CRT and it did not look easy. There was a fair old



Circuit diagram for the motherboard of the HP 3585 from the second service manual (A41: page 192), which can be found here: www.ko4bb.com/getsimple/index.php?id=manuals&dir=HP_Agilent

amount of accumulated dust around the EHT leads and components. This was probably the cause of the sparks; after a long spell of high humidity, the dust absorbed enough water to become conductive.

I cleaned everything out, including the interior of the EHT box, using rags and methylated spirits and then dried it all out. Then I noticed a small perspex cover which concealed a 1A fuse and a quick check revealed it had failed. I replaced it, thinking that it would instantly blow again, but magically the whole instrument lit up and the CRT display was bright and normal.

The instrument then functioned well for a year. Then one day, it refused to start up properly. All the LEDs on the front panel lit up but nothing else happened.

Switching the instrument off and on a couple of times brought it to life and that is how it operated for a few months until finally, nothing happened at switch-on except for the front panel lighting up. I left it for some time to gather cobwebs because I had another HP 3585a which worked properly, except its knobs, which meant that I could not control the tracking generator amplitude.

Eventually, I decided to tackle the fault by exchanging a few spare low voltage regulator PCBs that I had obtained from the internet. There are five of these in each instrument, so I changed them one by one but that didn't cure the fault.

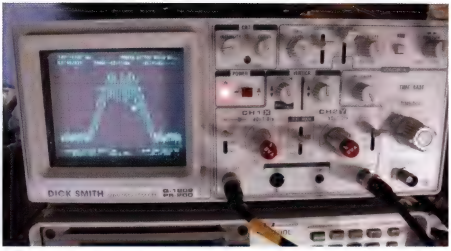
The service manual, which runs to three volumes and 884 pages, points out that one faulty board may be capable of damaging another so that the end result might be several damaged boards and this worried me a bit.

The output voltages from these boards measured correctly and that plus the fact that the five green status LEDs were all lit, suggested that the power supply was functioning correctly.

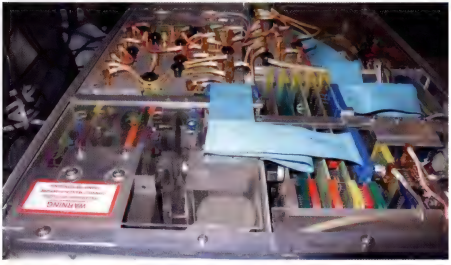
Again, I put the instrument aside, fearing that the fault was too elusive, and went back to the older working instrument.

Some time later, I decided that I had to throw it away or fix it. I decided to substitute the PCBs from the working unit and take a risk that I might end up with damaged boards and have two dud instruments.

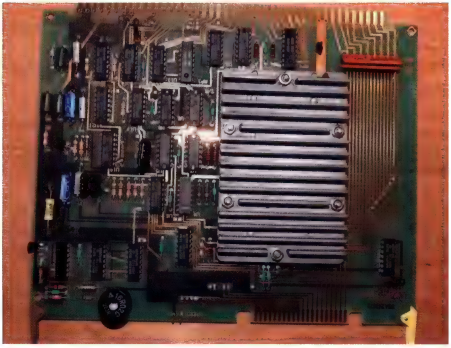
There are about 24 boards in total,



An analog oscilloscope was used temporarily as a replacement screen.



The inside of the spectrum analyser is packed with boards (24 in total).



The HP 3585 motherboard shown above, corresponding to the circuit diagram at left. The 80-pin CPU (U13) is located under the large ribbed heatsink.

many of which are difficult to access, so I just started at one end and replaced the suspect boards with the good ones.

Rather than swap in one board, check if it works and then swap it back, I decided to move all the known-good boards into the unit one by one, in case two or more boards were faulty. Then suddenly, after I replaced the central processor board, everything came to life again.

As it happened, I had a spare processor board on hand, amongst a set of boards that I had previously purchased from eBay for spares. It was horribly dirty but the unit worked with it in place, so I had two working instruments at last! But that is not the end of the story.

Ironically, just as I was finishing this story, a similar fault occurred and the instrument would not start up, even though some LEDs were flashing normally on the front panel. It came back to life when I substituted the processor board (03585-66541) from "old faithful".

Apparently, I now have two dud processor boards and there are none to be had on the internet. The usual parts sellers told me that they had sold all their processor boards. I was back to square one.

I tried to repair the faulty boards referring to the excellent repair manual; I replaced all the electrolytic capacitors (and the other capacitors for good measure) but nothing worked.

The voltages around the main ICs all measure good but there are 23 of them so replacing them would be a massive undertaking, even if they were available.

And then there is the main processor chip which is the size of my wallet and definitely not a standard item!

I found one internet seller that had three dud HP 3585 analysers for sale. He was asking $800-1,000 each for shipping but the photo of the instrument showed a very dim glimmer of a trace which indicated a healthy processor board, so I asked him if he would accept half price and pull out the desired PCB and post it to me via USPS for about $40.

After about 20 emails back and forth, we finally came to an agreement on price and the board arrived safely and it actually worked. The reason for the failure of these boards remain a mystery but I have kept the two dud boards for future spares. SC

USB Keyboard and Mouse Adaptor for Micros

How can you connect a keyboard, or a mouse, to a microcontroller, especially now that most keyboards and mouses have a USB plug? This Adaptor is the answer. It makes it simple to connect a USB keyboard or mouse to any micro! It's small, easy to build and it won't break the bank!

by Tim Blythman

A **keyboard or mouse** would be a great addition to your Micromite or Arduino project, especially given how cheap a USB keyboard or mouse is these days. But there hasn't been an easy way to do it.

Until now!

One of the most challenging parts of designing a project around a microcontroller is providing a way for the user to control it.

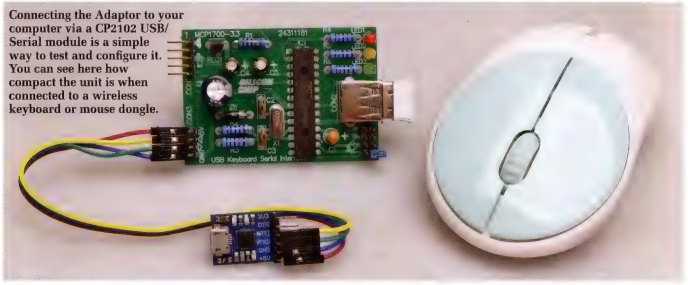
Touchscreens are great but let's face it: an on-screen keyboard is not particularly easy to use, and usually takes up most of the screen.

A touchscreen PLUS a physical keyboard is a way better user interface solution. And if you can add a mouse cursor, so much the better!

And there's the added bonus that many USB keyboards and mouses are wireless these days. How convenient is that, an input method for your microcontroller project that doesn't even need to be tethered to it via a cable?

And this is a far easier way to achieve that than a home-brew wireless communication system. It's just "plug and play".

We're using the term "mouses" as



Connecting the Adaptor to your computer via a CP2102 USB/Serial module is a simple way to test and configure it. You can see here how compact the unit is when connected to a wireless keyboard or mouse dongle.

the plural for a computer mouse, as opposed to "mice", which usually refers to the mammalian kind, or even "meeces" as you'd find in a comic!

The compact unit presented here bridges the gap between a USB keyboard or mouse and a simple microcontroller. The keyboard or mouse plugs into one side (or its tiny dongle, if it's wireless) and a serial data stream is produced from the other side that any micro would find dead easy to read.

There are various settings to adapt the serial data stream to your particular requirements, including a mode which allows detection of practically all keys on a keyboard with just a single byte transmitted for each keypress.

Similarly, for a mouse, there are multiple modes to choose from, including one which supports three movement axes and up to five buttons.

With USB hardware being cheap and plentiful, it's now possible to easily and cheaply add these peripherals to your latest project.

By the way, we know that you can also do this with a USB host shield or an Arduino Due. But our solution has two big advantages: (a) it is cheaper and (b) it's definitely easier for you, and smaller too.

Features & specifications

- Simple and low cost
- Accepts either a USB keyboard or mouse (two different firmware images)
- Translates key presses or mouse movement/clicks into serial data
- Just one pin on a micro required to receive either keyboard or mouse data
- Build two to connect both a keyboard and a mouse up to the same micro
- Configurable baud rate from 1200 to 115,200
- ASCII translation for keyboards with optional codes for special keys
- VT100 emulation option for keyboards
- Supports mouses with up to three axes and five buttons
- Configurable mouse update rate and scaling factor
- Onboard status LEDs
- Powered from 5V DC

How it works

The Adaptor has a USB Type-A socket at one end, for plugging in a keyboard or mouse, and a four-way pin header at the other end which has a standard TTL serial port interface and is also used to supply 5V DC power to the board (and keyboard/mouse).

Any device which can supply 5V and communicate via serial can therefore make use of a USB keyboard or mouse – wired or wireless!

When a keyboard is connected, the keystrokes are converted into data that is sent down the serial transmit line to whatever device is attached.

Similarly, when a mouse is plugged in, data is generated on the serial port when you move it or click the buttons. This data is designed to be easy for a microcontroller to interpret and act upon.

The USB Keyboard and Mouse Adaptor also has three LEDs to indicate its status. The red LED lights up when 5V power is applied.

When a compatible keyboard or mouse is connected, the red LED extinguishes and the green LED illuminates instead. The yellow LED flashes each time keyboard or mouse activity is detected and it lights up continuously while the unit is being configured.

There are also four jumpers on the board. JP1 can be used to enter set-up mode (you can also do this via the serial console). JP2 temporarily resets the configuration to default while JP3 permanently resets it to default upon power-up (ie, writes default settings to flash). When JP4 is inserted, configuration mode is not available, so the configuration can't be accidentally changed.

Circuit description

The circuit, shown in Fig.1, is based around a PIC32MX270 microcontroller, IC1. This is a slightly newer version of the micro used previously in the ASCII Video Terminal project (*July 2014;* **siliconchip.com.au/Article/7925**), the difference being that it has twice as much flash and RAM.

It's also closely related to the chip used for the 28-pin Micromite (*May-June 2014;* **siliconchip.com.au/Series/261**), which we have used in so many projects.

The only difference between the PIC32MX270 used here and the PIC32MX170 used for the Micromite is that the -270 version has USB support, with pins 21 & 22 able to be used either as general-purpose I/Os (GPIOs) as RB10/RB11 or for USB communication (D+/D-).

These are wired directly to the USB Type-A socket, CON2, which is also fed the board's 5V power supply, to power the keyboard or mouse.

The USB version of this chip has two fewer I/O pins than the non-USB version, which are instead used to supply power to the internal USB controller (USB3V3) and for USB bus voltage sensing (V_{BUS}).

IC1's clock source is 16MHz crystal X1, connected between its clock input and output pins (pins 9 & 10), along with 22pF load capacitors. This is required to ensure that the USB communication timings meet the specifications. IC1's internal PLL (phase-locked loop) multiplies this 16MHz source up to 48MHz for its instruction clock and that is then divided by four to get the required 12MHz USB clock.

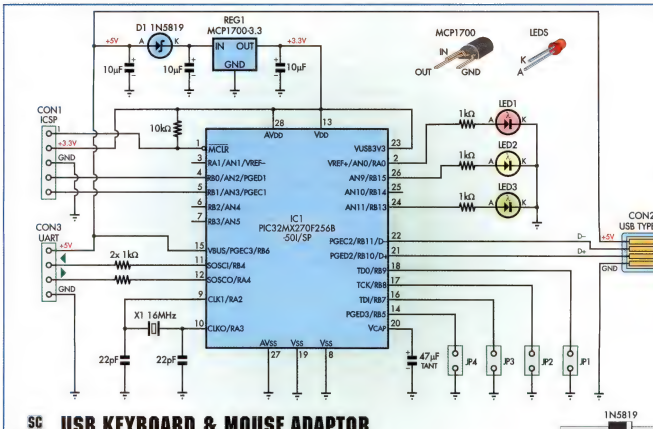
Indicator LEDs LED1-LED3 are driven by GPIO pins RA0, RB15 and RB13 respectively (pins 2, 26 & 24), via 1kΩ current-limiting resistors.

Jumper headers JP1-JP4 connect between GPIO pins RB9, 8, 7 and 5 (pins 18-16 & 14) and ground. Internal pull-ups on those pins keep them high when the headers are not shorted, allowing IC1 to detect the presence or absence of the four jumpers.

Power supply

IC1 requires a low-ESR capacitor between pin 20 (V_{CAP}) and ground, of at least 10µF, to filter its internal 1.8V core supply. To meet the low ESR requirement, we are specifying a 47µF tantalum capacitor, only because we have previously found that lower value tantalum capacitors do not always meet the ESR requirement of less than 1Ω.

That is why we have often used



USB KEYBOARD & MOUSE ADAPTOR

Fig.1: the circuit diagram for the USB Keyboard & Mouse Adaptor, which is based around PIC32 microcontroller IC1. It communicates directly with the USB keyboard or mouse plugged into CON2, which is powered from the external 5V supply. The micro translates any keystrokes or mouse movements received and sends them to the serial port on pins 2 & 3 of pin header CON3.

SMD ceramics in this role the past, as they can be relied upon to have a low ESR, even at 10µF. We've also found ceramics to be more reliable, long-term.

However, in this case, we've decided to stick with a through-hole component, hence the use of a tantalum capacitor.

Power is fed into the board via the 5V and GND connections of CON3, which also carries the serial data.

The supply has to be very close to 5V; ±5% is required by the USB specification, ie, 4.75-5.25V. This supply is used to power the USB keyboard or mouse directly.

Fortunately, most keyboards and mouses have modest power requirements, so as long as your supply can provide a couple of hundred milliamps, that should be plenty.

The 5V supply is bypassed by a 10µF capacitor, then fed via schottky diode D1 to another 10µF capacitor and regulated to 3.3V by REG1, an MCP1700 low-dropout (LDO) regulator. This has a 10µF output filter capacitor.

We've tested several such capacitors to ensure that they have an ESR of less than 2Ω as specified in the MCP1700 data sheet.

The 3.3V output of REG1 powers IC1 and is fed to its three supply pins: VDD (pin 13), analog VDD (AVDD, pin 28) and USB3V3 (pin 23), which powers the internal USB transceiver.

Diode D1 ensures that any high current pulses drawn from the 5V rail do not come from REG1's input filter capacitor and assists with the stability of the 3.3V rail when transients occur on the 5V rail.

The 10kΩ pull-up resistor connected between pin 1 (MCLR) and the 3.3V rail prevents spurious resets of the micro which may occur due to EMI or power supply transients. MCLR is connected to CON1, the in-circuit serial programming (ICSP) header, along with the 3.3V supply for IC1 and its PGED1 and PGEC1 programming pins. The pinout of IC1 suits a PICkit 3 or 4.

IC1 has two internal hardware UARTs (serial ports). These can be mapped to various combinations of pins.

In this case, we have set up U1TX on pin 11 (RPB4) and U1RX on pin 12 (RPA4). These go to CON3, the serial/power header, via 1kΩ series resistors. These allow the serial port to work safely with either 5V or 3.3V devices, as well as providing some extra ESD (static electricity) protection.

Operating modes

There are several different settings which can be changed to suit your requirements but the most important one for keyboards is the translation mode. It can be set to translate either to 7-bit ASCII, 8-bit ASCII or VT100.

In 7-bit ASCII mode, key presses will produce standard characters such as lower case or upper case letters, numbers, punctuation, space, Enter, tab, backspace and so on. Other key presses such as arrow keys, page up/down, print screen and so on are ignored.

If you have a number pad, numeric codes are produced in this mode but only when Num Lock is active.

Ctrl-letter key combinations also work in 7-bit ASCII mode. For ex-

ample, Ctrl-C maps to ASCII code 3, which is used by the Micromite and many other systems to stop the currently running program. Control plus the letters A-Z map to ASCII codes 1-26.

In 8-bit ASCII mode, all the same 7-bit ASCII characters are still sent but extended characters are also produced from other keypresses. This mode is useful if you need to be able to process presses of the arrow keys, home/end, delete, F-keys, modifier keypresses (Shift, Ctrl, Alt etc), non-numeric number pad keys and so on.

Rather than invent a new scheme, we've implemented the standard Arduino "Keyboard Modifiers" scheme, which you can view on the following web page: **www.arduino.cc/en/Reference/KeyboardModifiers**

However, that scheme is far from complete. For example, it does not provide any way of knowing when a modifier key such as Shift, Ctrl or Alt is released.

So there's no way to know for sure whether a key was pressed while one of these modifier keys were held down. And some keys on the keyboard, such as print screen and pause/break, are missing from the Arduino modifiers list.

So we've added to that list – see Table 1. Since the Arduino keyboard modifiers are a subset of ours, they are compatible; your software can merely ignore any codes it doesn't understand. But the new scheme gives you a much better idea of what keys the user is actually pressing. Note that all the added key up events have the same code as the key down events, plus 16 (hexadecimal 10).

VT100 emulation mode goes a step further and translates certain keypresses into commands or "escape sequences" which are compatible with the old-fashioned (1978!) VT100 video terminal. Those commands are still in use today in Unix-based operating systems. They allow for things like moving the cursor around the screen, erasing characters and so on.

The ASCII Video Terminal project that we mentioned earlier, from the July 2014 issue, is a VT100-compatible terminal.

So in theory, if you connected the USB Keyboard Adaptor up to the ASCII Video Terminal, you could then use the keyboard to move the cursor around the screen and type text wherever you wanted.

You can find a list of VT100 escape sequences in the ASCII Video Terminal article, on page 66 of our July 2014 issue.

The Adaptor doesn't produce all of those codes – just those which can be generated from a keyboard.

Another mode setting determines what happens when you press Enter on the keyboard.

The unit can either generate a single code: either carriage return (CR, ASCII 13) or line feed (LF, ASCII 10). Or it can generate two codes: CR, then LF. A carriage return typically moves the cursor to the left-hand side of the screen while line feed moves it down one line (and possibly scrolls the display if it's already at the bottom).

If you're programming the receiving micro yourself, a single CR (the default) or LF code would probably be easier to handle.

But you may need to set the unit to produce the CR/LF pair when using it with pre-existing software that expects that combination, such as a "dumb terminal", where this code pair moves the cursor to the start of the next line.

Mouse modes

There are three options for the serial data format produced when using the Adaptor with a mouse. In all modes, mouse movements are relative, so the receiving device must accumulate the movements to track the mouse cursor position.

The default mode is the Microsoft Serial Mouse format. This consists of three bytes of 7-bit data for each update, containing the current mouse button states and the horizontal and vertical movement in pixels since the last update.

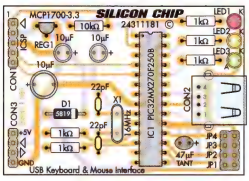
In this mode, we set the eighth bit of each byte to 1. The data can therefore be decoded as either 8-bit data with one stop bit or 7-bit data with two stop bits, but it is also compatible with systems that expect 7-bit data with one stop bit, as the extra bit simply appears as extra idle time between bytes.

The Microsoft Serial Mouse format only supports two buttons and eight bits of movement resolution in each axis, so we developed an eight-bit version that supports three buttons and nine bits of movement resolution. That is the second mouse mode that you can select.

Table 1 – 8-bit keyboard modifier codes

Key	Hexadecimal code
KEY_LEFT_CTRL	0x80
KEY_LEFT_SHIFT	0x81
KEY_LEFT_ALT	0x82
KEY_LEFT_GUI	0x83
KEY_RIGHT_CTRL	0x84
KEY_RIGHT_SHIFT	0x85
KEY_RIGHT_ALT	0x86
KEY_RIGHT_GUI	0x87
KEY_LEFT_CTRL_UP	0x90 *
KEY_LEFT_SHIFT_UP	0x91 *
KEY_LEFT_ALT_UP	0x92 *
KEY_LEFT_GUI_UP	0x93 *
KEY_RIGHT_CTRL_UP	0x94 *
KEY_RIGHT_SHIFT_UP	0x95 *
KEY_RIGHT_ALT_UP	0x96 *
KEY_RIGHT_GUI_UP	0x97 *
KEY_RETURN	0xB0
KEY_ESC	0xB1
KEY_BACKSPACE	0xB2
KEY_TAB	0xB3
KEY_F1	0xC2
KEY_F2	0xC3
KEY_F3	0xC4
KEY_F4	0xC5
KEY_F5	0xC6
KEY_F6	0xC7
KEY_F7	0xC8
KEY_F8	0xC9
KEY_F9	0xCA
KEY_F10	0xCB
KEY_F11	0xCC
KEY_F12	0xCD
KEY_INSERT	0xD1
KEY_HOME	0xD2
KEY_PAGE_UP	0xD3
KEY_DELETE	0xD4
KEY_END	0xD5
KEY_PAGE_DOWN	0xD6
KEY_RIGHT_ARROW	0xD7
KEY_LEFT_ARROW	0xD8
KEY_DOWN_ARROW	0xD9
KEY_UP_ARROW	0xDA
KEY_CAPS_LOCK_ON	0xE0 *
KEY_CAPS_LOCK_OFF	0xE1 *
KEY_SCROLL_LOCK_ON	0xE2 *
KEY_SCROLL_LOCK_OFF	0xE3 *
KEY_NUM_LOCK_ON	0xE4 *
KEY_NUM_LOCK_OFF	0xE5 *
KEY_PRINTSCREEN	0xE6 *
KEY_PAUSE_BREAK	0xE7 *

* added by us



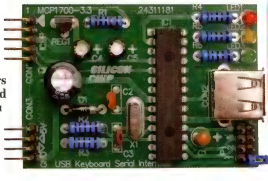


Fig.2: use this PCB overlay diagram and photo as a guide when building the Keyboard & Mouse Adaptor. IC1, D1, LEDs1-3 and the tantalum and aluminium electrolytic capacitors are all polarised, so must be fitted with the orientations shown. You can use a vertical or horizontal pin header for CON1 and CON3 to suit your application; note that CON1 is only required to program IC1 in-circuit.

The third mode produces human-readable CSV data, with four fields. The first field is a bitmap of the button states and it supports up to five buttons. The next three fields are three-axis delta values, corresponding to the x, y and z axes. Although not many mouses support a third (z) axis, this data is sent over USB, so we have included it in this mode.

Note that most of the mouses that we tried which had mouse wheels did not report mouse wheel rotation using the basic HID protocol, so it's unlikely that you will be able to detect rotation of the mouse wheel using this Adaptor.

The software

The software running on microcontroller IC1 is programmed to communicate using the USB "Human Input Device" or HID protocol, the standard used by keyboards and mouses (and also some other devices).

This requires the USB interface to run in "host mode", which is different from the "device mode" that you would use for communicating with a computer via its USB port.

The HID driver is from Microchip, which comes with several other different USB drivers in their "Harmony" library. This is integrated with their MPLAB X IDE (Integrated Development Environment).

The Harmony utility automatically generates the code for low-level USB interfacing, such as detecting and enumerating connected USB devices. We had to add code to activate the USB interface, query it and respond to events that occur.

So that allows us to get keystroke data from keyboards and mouse movement/click data from mouses. But there are further difficulties in converting the keystroke codes from a USB keyboard into a useful form of serial data.

For the keyboard version of the firmware, the Microchip USB library calls our user function every time a keyboard event occurs. Mostly, these are to report that a key has been pressed or released but there are also events indicating when a compatible keyboard is attached or detached. We use these events to change the status of the red and green LEDs.

Each report from the keyboard contains a list of which keys are currently depressed (up to six) and which combining keys are pressed (shift, Ctrl, Alt etc). The report needs to be filtered so that keys that are still down in subsequent reports are not detected as pressed again. These events are then decoded.

The keystroke events from the keyboard do not neatly map to the ASCII codes, so we need to perform some table lookups based on the mode and shift keys to determine what ASCII code to produce. The basic 7-bit ASCII codes such as letters, numbers and punctuation are handled first.

If the software can't find a match to a 7-bit ASCII code for a keystroke, then it checks whether Enter has been pressed, and if so, it generates either CR, LF or CR/LF, depending on the mode setting as explained above.

If the keystroke didn't correspond to a 7-bit ASCII code or Enter, and if 8-bit extended ASCII mode or VT100 mode are enabled, it then checks to see whether the keystroke should produce one or more codes to suit those schemes.

Finally, Num Lock, Caps Lock and Scroll Lock key presses are detected and internal flags set so that their states can be taken into account when decoding subsequent keys. A message is also sent back to the keyboard to update the respective status LEDs.

The mouse version of the firmware is somewhat simpler but works similarly. A function is called each time the mouse is moved or a button is clicked (or released) and it then formats and sends the corresponding serial data to the microcontroller.

Every time data is sent to the serial port, the yellow LED is switched on and a timer is started. The yellow LED is switched off after it has been on for 50ms, thus giving the effect of flashing briefly for each keystroke or mouse movement/clips.

Construction

The USB Keyboard & Mouse Adaptor is built on a compact PCB measuring 64mm x 44mm, which is coded 24311181. Use the PCB overlay diagram, Fig.2, as a guide during construction.

The following instructions assume you have the board orientated with the USB socket on the right and the single row header pins on the left, as shown in Fig.2.

There aren't many options that need to be considered when building this board. If you have a pre-programmed microcontroller, you can omit CON1, the ICSP programming header. It can always be installed later if necessary.

Start by fitting the resistors where shown. One is a 10kΩ type so don't get it mixed up with the others. If you have any doubt about the markings (they look similar), check the resistances with a multimeter.

D1 is the only diode, and it must be installed with its cathode band facing to the right. If you have a low profile HC49US crystal for X1, install it next, as it will probably sit lower than its accompanying capacitors.

Next on the list is the microcontroller, IC1. You can either solder it directly to the board or solder a socket and plug it in. The socket makes it easier to swap the chip but sockets can fail over time due to oxidisation, so it's up to you whether to use one.

Regardless, make sure you solder

the part in with the correct orientation, ie, the pin 1 dot/notch towards the top of the board.

The tantalum capacitor is next. It is polarised and will have a "+" marked on its body to indicate the positive lead, which should also be longer than the other. Make sure this lead goes into the pad marked with a "+" sign on the PCB. The ceramic capacitors can be fitted next. They are not polarised and can be installed either way.

Follow with the three regular electrolytic capacitors. Their longer lead is positive and the stripe on the can indicates the negative lead. The positive lead must be soldered to the pad marked with a "+" sign on the PCB. Note that one of the electrolytic capacitors is orientated differently than the others (the one with the more widely spaced pads).

Fit REG1 next. Its legs will need to be cranked outwards and then down to match the PCB footprint. Take care to mount it with the orientation shown in Fig.2.

The LEDs can now be installed. You can push them all the way down onto the board as we did, or bend their leads so that they face to the side, depending on how you are planning to use the board. Regardless, make sure that their anode (longer) lead goes to the pad on the left, away from the nearest edge of the board.

The various connectors and jumper headers can be mounted next. CON2 will only fit one way, with the socket opening projecting out over the edge of the PCB. Ensure it is flush before soldering its pins.

As mentioned earlier, CON1 is only needed if your PIC is not yet programmed. You can use a vertical or right-angle header for both CON1 and CON3. If your crystal is a full-height type, now would be a good time to solder it in place.

If you fitted a socket for IC1 earlier, straighten the IC pins before plugging it into the socket, ensuring that none of the legs fold up under it and that its pin 1 dot/notch lines up with the notch on the socket, as shown in Fig.2.

Programming IC1

If you have a pre-programmed PIC, you don't need to worry about programming it and you can proceed to the next section for testing.

Note that if you're using a PICkit 4 to program the chip (which is a bit wider than a PICkit 3), when you plug it into CON1, it may touch the pins of CON3. You should still be able to get a good enough connection to program IC1 despite this.

One potential solution would be to install a vertical header for CON1 and a horizontal header for CON3, or leave CON3 off the board until you've programmed IC1.

Microchip's free MPLAB X IDE or IPE software can be used with a PICkit 3 or PICkit 4 to load the firmware into the microcontroller. Alternatively, you could build the Microbridge programmer, described in our May 2017 issue (see **siliconchip.com.au/Article/10648**).

If you don't have a USB/Serial converter (or something similar) to use for testing, then you can use a Microbridge, as this can act as a USB/Serial converter as well as a PIC32 programmer.

Connect your programmer of choice to CON1, ensuring that the arrowed pin (pin 1) on the programmer aligns with the arrowed pin on the PCB. If using the MPLAB X IPE, choose the PIC32MX270F256B micro from the list, and ensure that the "Power target circuit from tool" option is selected.

Open the HEX file (available for download from the SILICON CHIP website) and then press the Program button. Make sure you are using the appropriate HEX file depending on whether you are programming the device to operate with a keyboard or mouse; they have a different file name suffix.

Check the progress display at the bottom of the window to ensure that the firmware upload is successful.

The red LED should then illuminate, indicating that the USB Keyboard & Mouse Adaptor is waiting for a keyboard or mouse to be connected.

Testing

For initial testing and familiarisation with how the USB Keyboard & Mouse Adaptor works, we recommend that you connect it to a PC using a USB/Serial converter, eg, one based on the CP2102 chip. Four wires need to be connected to CON3: 5V, GND

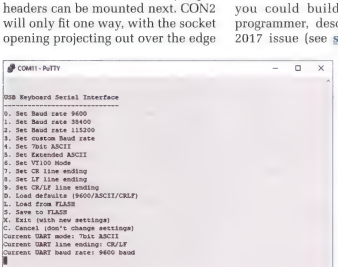


Fig.3: this is the settings screen of the USB Keyboard & Mouse Adaptor, when programmed with the firmware suitable for interfacing with keyboards. If you have set a very low baud rate, it may take a few seconds for this to be displayed. The currently selected parameters are shown below the menu.

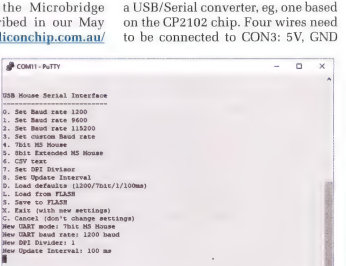


Fig.4: similarly, the settings screen shown when using the Adaptor in mouse mode. The default baud rate in this mode is lower (1200) for compatibility with the Microsoft Serial Mouse protocol but you can change it if necessary. Options 4, 5 & 6 allow you to select between the three different data formats, with each mode having different capabilities – see Tables 2-4 for details.

Table 2 – Microsoft Serial Mouse data format

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	1	1	Left button	Right button	Y7	Y6	X7	X6
1	1	0	X5	X4	X3	X2	X1	X0
2	1	0	Y5	Y4	Y3	Y2	Y1	Y

Table 3 – 8-bit Mouse data format

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	1	Left button	Right button	Middle button	Y8	Y7	X8	X7
1	0	X6	X5	X4	X3	X2	X1	X0
2	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0

Table 4 – CSV Mouse data format

Each entry has the form: Buttons,delta x,delta y,delta z<CR><LF>
Where Buttons is an 8-bit value:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Left	Right	Middle	Button	Button	0	0	0
Button	Button	Button	4	5			

These tables show the three data formats available when using the mouse version of the firmware. The Microsoft Serial Mouse data format is identical to that used on the Microsoft Mouse 2.0 (from 1985). How's that for backward compatibility!

and the two serial data lines. We have used arrows to indicate the data flow of the two serial data lines, as TX and RX markings are often ambiguous.

Connect the RX line on the USB/serial adaptor to the pin with the arrow that's pointing towards the edge of the PCB, and the TX line to the pin with the arrow that's pointing into the middle of the PCB. Then plug the USB/Serial adapter module into a computer. The red LED on the board should light up.

Now plug a USB keyboard or mouse (or wireless keyboard/mouse dongle) into the socket on the PCB. After around a second, the red LED should go out and the green LED should turn on.

If you do not get the green LED lighting up, then check the construction and component values. Also, make sure that you have loaded the keyboard firmware if you are using a keyboard, and the mouse firmware if you are using a mouse.

If all is well, open up the serial terminal program of choice (eg, PuTTY, TeraTerm Pro and the Arduino Serial Monitor all are suitable) and set the baud rate to 9600 (for the keyboard version) or 1200 (for the mouse version).

Now type on the keyboard or move the mouse. You should see data appear in the serial console.

For the keyboard version, if you press letter keys, you should see the corresponding letter. In the default mouse mode, the data which appears will probably look like gibberish. You may wish to change it to CSV mode, at least temporarily, to get more legible data (the procedure is described below).

If you are using the Arduino Serial monitor and the keyboard firmware, note that you may not get the usual effect of the Backspace key; on our system, it produced a black rectangle rather than deleting the previous character.

Changing the settings

On your computer, use the serial terminal program to send a "~" character to the device. On the Arduino Serial Monitor, you may need to press Enter after typing this, to send the data.

The settings menu as seen in Fig.3 (for keyboards) or Fig.4 (for mouses) should appear in the terminal, and the yellow LED on the unit will light up solid to indicate that you are in settings mode.

You can change most of the settings with single keystrokes. The action is confirmed on the terminal and the menu is re-displayed with the new settings shown. These settings are not active until the "X" key is pressed to activate them.

They can be saved to flash with the "S" command, in which case they will become active the next time the device restarts and the settings are loaded from flash.

The purpose of most of the settings should be intuitive. If you change the baud rate, you will need to also change your terminal program's baud rate after pressing "X".

The baud rate can be set to pratically any value between 100 and 1,000,000, with a few common values such as 9600, 38,400 and 115,200 available directly from the menu.

Serial data is always sent in the standard 8N1 (8 data bits, no parity, 1 stop bit) format.

As mentioned earlier, the default baud rate in keyboard mode is 9600, as this can easily be handled by a software serial port and it's more than fast enough for typing.

The default baud rate in mouse mode is 1200 because that is what is used by default in the Microsoft Serial Mouse protocol and again, it's fast enough in most cases. But you could bump it up to 9600 baud or higher, if required for your application.

If you change the keyboard mode to VT100 emulation and set your terminal emulator to VT100 mode, you should be able to use the arrow keys on the keyboard to move the cursor around the terminal and type text in various locations. That will confirm that VT100 mode is operating correctly.

Note that instead of sending a "~" character, you can also get into the settings menu by inserting JP1. And if you change the settings and manage to get the device into a weird mode (eg, an unknown baud rate), you can temporarily switch it back to the default settings by inserting JP2.

Removing JP2 and power cycling the unit will revert it back to whatever configuration you last saved.

To permanently revert the settings back to the default (you can change them again later), place a shorting block on the JP3 header and cycle power to the unit. You can then remove the shorting block.

The default configuration values will have been written to flash. And once you have set up the unit the way you need it, you can place a shorting block on JP4 to prevent accidental configuration changes.

Mouse-specific settings

Besides the three possible modes described above, there are two additional mouse-specific settings: the DPI Divisor (movement scaling factor) and Update Interval.

The internal mouse movement pixel count is divided by the DPI Divisor before being sent to the serial port. Some mouses report movement values which overflow some of the data formats, so this setting provides a way of scaling the movement values down to a suitable range.

You may also find that specific scaling values make it simpler to handle mouse movements in your micro firmware.

The Update Interval is specified in milliseconds. It is the minimum interval between movement updates; button press or release events are reported immediately.

The USB interface can operate at up to 125Hz, ie, 8ms between updates. If your application doesn't need such a high update rate or just can't handle it, you can use the update rate setting to increase the interval. We found that 100ms (giving 10Hz updates) was adequate for most micro-based applications.

Connecting it to your target micro

When connecting the USB Keyboard and Mouse Adaptor to a micro, you usually only need to run three wires. The serial receive line (next to GND on CON3) does not normally need to be connected.

If you're using an Arduino Uno or similar device, with only one hardware serial port that's already used for debugging/programming, we suggest that you configure a receive-only software serial port to connect to each Keyboard/Mouse Adaptor.

These are usually limited in baud rate because they use too many CPU cycles at higher baud rates. But 9600 baud is fast enough for this application and it will typically only take up a single digital I/O pin.

Ensure that the device you are connecting to has a stable 5V supply which can provide enough power to run the connected keyboard or mouse.

If your micro was already set up to receive data via a serial terminal, you can use the Keyboard Adaptor in 7-bit ASCII mode and simply wire it up to that terminal. You should not need to make any changes to enter commands.

Note that you may not be able to feed data directly into the serial console of a micro board if that serial port is permanently wired to a USB/Serial converter chip.

That chip may override any data coming from the Adaptor.

In that case, you will need to use a separate serial port (hardware-based or software-based) to handle the data.

Linux terminal consoles can work in VT100 compatible mode. In the case of small single board computers such as the Raspberry Pi, the console is often broken out to a physical UART on the GPIO header.

So the USB Keyboard and Mouse Adaptor can be directly connected there and set up in VT100 mode, to drive the console directly.

Similarly, if you are using the Keyboard Adaptor with a Micromite, you may need to do nothing more than connect it up to the serial console and configure the Adaptor for the correct baud rate and terminal mode.

If you are using the Micromite Plus Explore 100 with an SSD1963-based 5-inch (or larger) LCD panel, you will then have a complete stand-alone system, with console text displayed on the LCD and updated via the USB keyboard.

We suggest you use VT100 mode in this case. The Explore 100 does already have a keyboard connector, but it's the ancient PS/2 type; suitable keyboards are getting hard to find.

Handling mouse and keyboard data in your software

In many cases, we expect that you will want to write specific software to interpret key presses, and this will almost certainly be the case if you are using a mouse. You will therefore need to set up one or more serial ports with the correct baud rate, wire up the board(s) to their receive pins, and then periodically check to see whether data has been received on those ports.

When data is received, your program will need to decide what action to take.

For example, it could compare the received key codes to a list of expected codes and execute a different function depending on which key is pressed.

Since the mouse data is more tricky to interpret than keyboard data, we have written a sample Arduino sketch to read and decode the mouse data. You can download it from the Silicon Chip website, in the same download package as the firmware.

If you plan to decode the mouse data yourself, the three data format are explained in Tables 2-4. SC

Parts list – USB Micro Keyboard and Mouse Interface

1 double-sided PCB, 64mm x 44mm, coded 24311181
1 5-pin vertical or right-angle header (CON1)
1 USB Type-A socket (CON2)
1 4-pin vertical or right-angle header (CON3)
1 2x4 pin header (JP1-JP4)
1 jumper shunt (JP1 *or* JP2 *or* JP3 *or* JP4)
1 16MHz HC-49/U or HC-49/US crystal (X1)

Semiconductors
1 PIC32MX270F256B-50I/SP (IC1), programmed with 2431118K.HEX (for use with a keyboard) ***or*** 2431118M.HEX (for use with a mouse)
1 1N5819 schottky diode (D1)
1 3mm red LED (LED1)
1 3mm yellow LED (LED2)
1 3mm green LED (LED3)
1 MCP1700-3.3 3.3V linear regulator, TO-92 package (REG1)

Capacitors
3 10µF 16V electrolytic
1 47µF 6V tantalum
2 22pF ceramic

Resistors (1/4W or 1/2W 1% metal film)
1 10kΩ 5 1kΩ

ALTRONICS

Build It Yourself Electronics Centre®

Catalogue Clearout!

Help us clear the decks for the new 2019-20 catalogue arriving next month.

Install your own CCTV system & save $$$

Great size for a small business or family home. Records and transmits 4 cameras at once. Each pack includes: • 4x 2MP digital video recorder (1080p recording at 25fps on all channels) • Pro grade 4MP resolution cameras • 20m BNC & power combo leads • Power splitter lead • Power supply • All cameras are weatherproof

• WD® CCTV HARD DRIVES TO SUIT: 1TB $110 (D 5514) 2TB $155 (D 5515)

NEW RELEASES...

64x32 RGB LED Panel

These linkable panels are ideal for making highly visible scrolling sign information readouts, clocks and timers. Readable up to 10m away. 5mm pitch LEDs. 384x192mm.

Make your own full colour sign

$99

Z 6518

Space Saver Multimeter

Just 16mm thick!

Not much bigger than your average mobile phone, this auto-ranging meter saves space in your tool box. Offers true RMS accuracy with relative mode and non-contact AC detection.

$99

Q 1084

Auto Ranging True RMS Meter

NEW MODEL!

With non-contact AC voltage detection in-built! An affordable auto-ranging meter with True RMS accuracy for AC voltages. Plus temperature measurement (probe included).

$39.95

Q 1134A

Vandal Resistant RFID Entryway Keypad

Weather & vandal resistant!

$165

Designed to control a door strike for home or business security installations. In-built proximity EM card reader & door bell. IP54 rated.

Phone Holder with Wireless Charging

Windscreen or air vent mount

$44.95

Simply place your phone in the holder to keep it topped up, whilst you're driving! Great for Uber drivers or road reps.

O 2207

Lithium-Ion Car Jump Starter

$159

M 8195A

Suits 12V battery vehicles. 20000mAh rated battery provides up to 1000A peak output when cranking. Two USB ports are provided for charging devices (like a giant battery bank!). It also has a super bright 1W LED torch in built. • 178L x 84W x 450mm.

M 8199

Compact go anywhere power station

$199

This multi-function portable solar generator/42,000mAh battery bank is ideal for outdoor activities. Power 240V AC appliances while you're out in the sticks! Plus 2.1mm DC power and USB charging outputs.

M 8627B

Laptop & USB Car Charger

Simply plugs into a car accessory socket. Up to 90W power output. Includes 9 laptop adaptors - see web for compatability list.

12V Battery Maintainer

Provides a trickle of power to your car, caravan or boat battery to keep it topped up when parked for long periods. 355x125mm panel size. Suits 12V batteries only.

N 0700

M 8623B

USB Car Charger With Readout

Max 3.1A USB charging. Displays battery voltage & output current.

Multi-Stage Weatherproof Vehicle Battery Chargers

Each model utilises a microprocessor to ensure your battery is maintained in tip-top condition whenever you need it. Helps to extend battery service life. Suitable for permanent connection. Great for caravans & seldom used vehicles.

$99

M 8534 6/12V 4.5A 7 Stage

$195

M 8536 12V 10A 10 Stage

Dual 12V Car Battery Isolator Kit

Provides everything you need to wire up a secondary battery in your vehicle - vital for powering appliances at campsites, inverters etc, and isolating the primary battery so you have enough juice to start your car! Instructions included.

See back page for store locations or visit: www.altronics.com.au/storelocations

Sale pricing ends February 28th 2019.

NEED PA GEAR FOR EVENTS OR FUNCTIONS? WE ARE THE PA SPECIALISTS!

Okayo® Makes Portable Event Sound Easy!

The new PA of choice for schools, wedding celebrants and places of worship. This robust, lightweight 60W PA system is the perfect portable sound solution with superb vocal reproduction. The high efficiency design provides 4 hours of use without the need for mains power! Works with wired or UHF wireless microphone. Includes UHF wireless mic receiver & CD/MP3 audio player. 230D x 300W x 470Hmm. Protect your investment with a heavy duty cover. C 7186 $41.95.

Tuned for superior vocal performance & clarity.

Rear

C 7182C

$999

PACK PRICE!

WIRELESS MIC PACKAGE:
Includes your choice of handheld microphone or lavalier beltpack (with mic). **Total saving of $354!**

$199

Ideal for clubs & organisations.

C 8884

UHF Wireless Microphone Pack

WOW, a pro grade package with two handheld transmitters for under $200! Offers up to 60m range line of sight in ideal conditions. Offers wireless freedom without sacrificing speech quality. XLR/6.35mm output. Requires 4xAA batteries (lithium AA 2pk $4.95ea S 4906).

Entertainers Mic

One of our all time best selling units, with superb reproduction and outstanding value. Diecast body. Includes 6m XLR cable.

SAVE $20

$99

C 0392

SAVE 22%

$33

A 2620

Portable Micro Mixer

Powered by 9V battery or plugpack (M 8923 $17.95) this tiny mixer is perfect for small productions. Mixes four 6.35mm mics.

Great for home recording!

$129

A 2548

4 Channel USB Mixer With Equaliser & Effects.

Want to get into recording podcasts, voice overs or making your own samples? This mini USB mixer connects directly to your PC or Mac, takes up very little desk space and is powered directly from USB - making it highly portable. Includes 3 band EQ and effects. 124W x 157D x 40Hmm.

SAVE 23%

$42

A 1109A

Instant Bluetooth® audio for any amplifier!

Pairs with your phone & stream instantly to your existing audio system. Includes 3.5mm lead. Buy P 6020 1.5m lead ($6) to hook up to RCA input on most amps.

SAVE $20

$79

A 0920

Wireless Infra-Red Repeater

Use your remote control up to 200m away (line of sight) from your equipment. Perfect for controlling your AV system from the patio or entertaining area. Includes plugpacks, IR emitter & receiver.

SAVE 25%

$26

X 0604A

Bluetooth FM Audio Player

Transmits bluetooth audio from your phone (music, phone calls etc) to your cars FM radio. **Plus it's also a dual USB charger!**

A 3216A

SAVE 10%

$125

Long Distance HDMI Sender

As used by hundreds of commercial AV installs! Send 1080p from a HDMI source up to 50m over Cat5e/6 UTP. Includes TX, RX & plugpacks.

NEW!

$199

A 4201

Bluetooth® 2x50W Amp

Stream audio directly from your device to yourspeakers in the study or entertaining area. 3.5mm and RCA inputs. Class D design. Internal headphone amplifier.

SAVE 15%

$75

A 2710

USB Background Music Player

Simply plug in a USB stick, connect the RCA output to your amplifier & press play! It even automatically loops the music. Requires 12VDC plugpack M9273A $16.95.

SAVE 20%

$55

D 2359

USB C to HDMI Adaptor

Provides USB A & HDMI output up to 4K @ 60Hz for USB C devices.

$279

SAVE $120

C 0857

Opus One® 8" Ceiling Speakers

Featuring woven carbon fibre woofer & titanium-dome tweeter for the ultimate in home theatre response! ▪ Bass & treble control switches ▪ Vented magnets ▪ Easy flip-lock installation ▪ Aluminium grilles

C 0856

$229

SAVE $120

Opus One® 8" Wall Speakers

PLUS BONUS BACKBOXES VALUED AT $45! (C 0855)

Featuring woven carbon fibre woofer & titanium-dome tweeter for the ultimate in home theatre response! ▪ Bass & treble control switches ▪ Vented magnets ▪ Easy flip-lock installation ▪ Aluminium grilles

C 0844

$64

HALF PRICE!

Weatherproof 6x9" Vehicle Speakers

Maintenance free outdoor sound. These weatherproof 6x9" speakers are designed for long life in marine or tropical areas. Also great for caravans. 50W RMS. 4Ω

C 0815

$79

SAVE $30

All your home entertainment in one box.

Stream direct to your TV from your favourite services such as Netflix, YouTube and more. Capable of streaming stunning 4K videos @ 60fps. Requires 2A USB power supply. Pair it with our # 0981 wireless keyboard/trackpad for $29.95.

$79

SAVE $40

C 8335

5.8Ghz Wireless AV Sender

Transmit stereo audio & composite video without cables from room to room. 30m range. IR sender built in. Includes transmitter, receiver & plugpacks.

Shop online 24/7 @ www.altronics.com.au **1300 797 007**

Do-It-All Multimeter

With in-built AC mains detection.

This is one of the best DMMs we have evaluated when it comes to build quality and feature set. Its perfect for the serious electronics enthusiast, electrical tradesperson or service tech. 3.75 digit display features a LCD bargraph and helpful mode indicators. Includes carry case, temp probe, insulated test leads and 9V battery.

SAVE $26

$99 Q 1068

Super-Tough DMM. Built like a tank!

This new multimeter is built tough with water and dust resistance, plus a impact resistant case for the rough and tumble of every day use in the field. Auto ranging design offers a feature list as long as your arm with a clear large digit backlit display. Includes carry case & test leads. See web for full spec list.

SAVE $50

$149 Q 1069

SAVE $66

$169 T 2444A

Whisk away those soldering fumes!

#1 choice for schools! This 60W soldering station has a powerful in-built fume exhaust fan which sucks away the smoke when soldering. The active filter helps to reduce airborne pollutants in your workshop. Durable metal construction.

Micron® Combo Soldering & Vacuum Desoldering Station

Save space on your bench with this top performing 60W soldering iron and 90W vacuum desoldering station. Removes a 16 pin through-hole IC in 30 seconds! Sucks molten solder away from components & pads in no time and is easily cleaned. 160° to 480°C adjustable. Includes 0.2mm soldering tip and three desoldering tips.

SAVE $45

$350 T 2050

Get a close up view with a desktop microscope

This high resolution 1.3 megapixel 200X USB microscope allows close up inspection of just about anything! USB PC interface plus HDMI output for monitor connection. 220x magnification with 10-30mm focal length. In-built 2.4" LCD.

$230 SAVE $59 X 4306

TOP WORKBENCH DEALS FOR DIAGNOSIS & REPAIR.

$139 Q 2120

SAVE $60

Battery Health Analyser

Detects and analyses voltage, cold cranking amperes, resistance and cell condition in 12V lead-acid cells. Easy connection and on screen menu driven operation. Ideal for vehicle servicing or checking 12V SLA cells in battery backup systems.

SAVE $60

$129 Q 0966

AC/DC Clamp Meter

Accurately measures AC or DC current to a 600A! Includes True RMS AC measurement, resistance, temperature, capacitance, zero & hold functions - All supplied with carry case & test leads.

Q 1289

SAVE $80

$119

Measure temperature without touching.

Twin laser beams for precise measurement between -50°C and 1050°C with 30:1 optical resolution. Adjustable emmivisity to cater for different surfaces. It even connects to an external probe. 2% accuracy.

T 2937A

NEW!

$12.50

SUPER HANDY!

Mini Hot Melt Glue Gun

Easy to use hot glue gun for crafts and hobbies. 12pk glue sticks $4.90 (T 2938A)

T 2247A

$40

SAVE 27%

Accurate Digital Vernier Calipers

Precision measuring with ease! 150mm length, suitable for measuring internal, external and depth dimensions. 0.01mm, 0.0005" and 1/128th" display.

T 2486

NEW!

$39.95

Iroda® Mini Blow Torch

A 1300°C blow torch with adjustable gas feed for a variety of tasks such as brazing and model making. Refill with Iroda gas T 2451 $8.50.

Easy data cable testing.

Measures cable length, traces cable location, finds cable breakages & provides PoE/ping testing. Provides a suite of test functions for comms/CCTV installers with easy on-screen adjustments. It even logs readings to Micro SD card (16GB D 0328 $13.95).

SAVE $44

$315 Q 1346

NEW!

D 3009

$49.95

PoE Network Tester

Test live ethernet cabling for data and power. Works with any 802.3af/at ports/cabling. Ideal for data/comms installers.

Network Cable Tracer

A must have for IT technicians! Combines a cable tracer & tester in one unit. Injects an audible signal down the line, making it easy to find specific lead. Requires 3 x AA and 1 x 9V batteries.

SAVE $20

$89 Q 1341

DESIGN & BUILD YOUR OWN GADGETS...

$169
Z 6516 7" 1024x600

$139
Z 6514 7" 800x600

$99.95
Z 6513 5" 800x480

Large Touchscreens For Raspberry Pi®

• Great for integrated projects, mini game consoles, information stands, mini PCs etc • Works with raspbian & ubuntu • Easy HDMI connection. Z 6302C Raspberry Pi to suit (Model 3B+) $75.

$44.95
Z 6425

Raspberry Pi POE Hat

Allows you to power your Pi over ethernet. Great for remote IoT applications. (Model 3 B+ only).

$19.95
S 9265

USB PoE Splitter

• Power a micro USB device over 802.3af PoE. • Eliminates the need for a power supply at the end of the cable run. • 5V 2.4A max.

$50
SAVE 24%
Z 6532

Nano Arduino Bluetooth Board

The Bluno Nano offers a compact atmega328p platform with in-built Bluetooth 4.0 low energy for easy connectivity. Just 53x19mm in size - great for portable designs.

$45
SAVE 24%
K 9650

Arduino Keypad Plate

Perfect for Arduino based access control, security and automation designs, this handy wallplate has a atmega328p chip and is suitable for use with standard shields.

$12
SAVE 25%
Z 6349

ATMega328P Lilypad Board

Great for moving UNO based designs & code into e-textile projects.

$10
SAVE 15%
Z 6307

$15
SAVE 40%
Z 6347

ProtoHAT for Raspberry Pi®

HAT board with soldermasked 0.1" holes and stackable header so you dont lose access to the GPIO. Pi sold separately.

ESP32 Wi-Fi Bluetooth/BLE Module

Provides 2.4GHz Wi-Fi and bluetooth on board. Requires SMD soldering for assembly.

$79
SAVE $40
Z 6311

37 In 1 Arduino Sensor Kit

A huge array of sensors for building into your next project design. See website for complete listing.

$10
SAVE 33%
Z 6391

3 Axis Digital Compass

Converts magnetic field to a differential voltage for heading information. 3-5V input.

$45
SAVE 15%
Z 6467

Ethernet IoT Arduino Development Board

Connect your Arduino design to the internet-of-things with this handy W5500 ethernet board with atmega328p on board. Fully compatible with UNO with integrated USB download & micro SD card slot.

$24.95
NEW!
Z 6381

NodeMCU ESP8266 Board

With Wi-Fi for easy plug and play connected projects. GPIO breakout pins, full USB-serial interface and pre-flashed NodeMCU in one compact package!

$27
SAVE 27%
Z 6510

2.8" Touch Arduino UNO Shield

A 240x320px touchscreen shield for Arduino utilising the ILI9325 chipset. 3.3V input.

$25
SAVE 15%
Z 6527

3.2" TFT Arduino Mega Shield

A 480x320 display screen shield for the Mega utilising the ILI9481 chipset. 5V/3.3V input.

$45
SAVE 35%
Z 6332

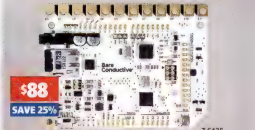
U-Blox Neo-6M GPS Shield

Add GPS positioning to a Arduino project. 3.3/5V logic level. Includes 28dB active antenna. 3.3/5V input, standard shield dimensions/pin outs.

$25
SAVE 24%
Z 6540

Arduino USB Programmer

Great for reprogramming your own atmega chips. Includes 6 and 10 pin cables.



$88
SAVE 25%
Z 6435

Touch Board With Arduino

Save & Makes projects interactive. Create sensors with the Touch Board's 12 electrodes and trigger sounds through its MP3 player. Works with croc clips, copper tape, solder, e-textiles and conductive paint (see below).

$50
SAVE 24%
Z 6430

Pi-Cap For Raspberry Pi®

The Pi-Cap allows the Raspberry Pi to interface to the physical adding precise capacitive touch, proximity sensing and high quality audio to your Pi.

$39.95
T 3133
50ml Jar

$15.50

Bare Conductive® Paint

Draw real circuits on almost any surface! Great for repairs or experimenting.

ALTRONICS

Build It Yourself Electronics Centres

VIC
- Springvale: 891 Princes Hwy 03 9549 2188
- Airport West: 5 Dromana Ave NEW! 03 9549 2121

NSW
- Auburn: 15 Short St 02 8748 5388

QLD
- Virginia: 1870 Sandgate Rd 07 3441 2810

SA
- Prospect: 316 Main Nth Rd NEW! 08 8209 8010

WA
- Perth: 174 Roe St 08 9428 2188
- Balcatta: 7/58 Erindale Rd 08 9428 2167
- Cannington: 5/1326 Albany Hwy 08 9428 2168
- Midland: 1/212 Gt Eastern Hwy 08 9428 2169
- Myaree: 5A/116 N Lake Rd 08 9428 2170

Or find a local reseller at:

www.altronics.au/resellers

Please Note: Resellers have to pay the cost of freight & insurance. Therefore the range of stocked products & prices charged by individual resellers may vary from our catalogue.

Sale Ends February 28th 2019

Phone: 1300 797 007 Fax: 1300 789 777

Mail Orders: mailorder@altronics.com.au

© Altronics 2019, E&OE. Prices stated herein are only valid until date shown or until stocks run out. Prices include GST and exclude freight and insurance. See latest catalogue for freight rates.

2600 B

BUILD-IT-YOURSELF DAB+ WITH FM AM and a Touchscreen Interface using an Explore100

Digital Audio Broadcasting

Last month, we introduced our new digital radio design which is a DIY world-first: a DAB+ radio which will also tune into FM and AM broadcasts. It has a slew of excellent features such as a 5-inch colour touch-screen interface, built-in stereo headphone and speaker amplifiers, digital audio outputs and infrared remote control. Let's start building it!

By Duraid Madina and Nicholas Vinen

Last month's article had all the details on this radio's circuit design and an explanation of how it works. All the circuitry shown last month is hosted on a single, compact board as shown here.

Most of the components are surface-mounting types; many of them are only available as SMDs so we decided that we might as well go the "whole hog" and use them extensively.

As we explained last month, where possible, we've chosen larger and easier-to-solder components where possible, so anyone with a bit of practice soldering SMDs should be able to manage it.

And we also explained that we are going to offer PCBs with the trickiest (RF) parts pre-soldered. We are in the process of sourcing the components to build those and we'll have more details on how you can purchase those next month (or you can check our online shop to see when they become available).

We strongly suggest that if you

The DAB+/FM/AM Tuner uses the Micromite Plus Explore 100 module as its controller, station selector, volume setting and so on. This touch-screen module is perfect for the task and also saves a bewildering array of switches and knobs! See the Micromite Plus Explore 100 articles in September and October 2016 – siliconchip.com.au/Series/304

want to build this radio but are not comfortable working with fine-pitch SMDs, you start with the partially pre-assembled board. It will make your life so much easier.

Practically speaking, if you've never soldered any SMDs before, you should probably start with a simpler project first.

Once you're more comfortable working with them, you can move onto this one.

You may even want to experiment with soldering some cheap SMDs onto scrap board to gain some experience before tackling this one!

Sourcing the parts

As well as sourcing the PCB and parts for the radio board described here, if you don't already have one, you will also need to purchase or build a Micromite Explore 100 module.

You will also need to source a 5-inch colour touchscreen to suit. They are available from a variety of sources including ebay and AliExpress.

Make sure you get the common version with a 40-pin header on the right-hand side of the screen. The LCD PCB is usually blue.

One option for building the Explore 100 is to purchase a short-form kit from our online shop, Cat SC3834 (siliconchip.com.au/Shop/20/3834). It includes everything you need to build the Explore 100 except for the LCD screen.

There are a few SMDs on that board, including the 100-pin PIC32 processor. But they are not especially difficult to solder, at least, compared to the 48-pin QFN radio chip.

Building and testing the Explore 100

The circuit details of the Explore 100 module were published in the September 2016 issue of SILICON CHIP while the construction details were given in the October 2016 issue (see siliconchip.com.au/Series/304). We won't repeat them here; however, if you don't have that issue, the process is relatively straightforward.

Briefly, you need to fit SMDs IC1 and Q1 first, being very careful to orientate and align them correctly and ensure that all the fillets are properly formed and no pins are shorted. Then solder the 10µF SMD capacitor in place, near IC1.

Next, install the through-hole components are shown on the PCB silk-screen printing. These consist of nine resistors, 13 ceramic capacitors, two electrolytic capacitors, three LEDs, one crystal, one transistor, one regulator, one tactile switch and numerous connectors.

The LED cathodes (shorter leads) go into the holes nearest the adjacent PCB edge.

When fitting the connectors, make sure that CON6 and CON9 are fitted to the underside. You don't need to fit CON1, CON4, CON5, CON7, CON10, CON13, CON14 or the headers for the real-time clock. But if your kit comes with those parts, it won't hurt to install them anyway.

We do recommend that you fit JP1 as it will aid in testing.

If you haven't used a pre-programmed PIC32 then the next step is to program it using a PICkit 3 or 4 (or similar) in-circuit serial programming (ICSP) tool.

This is done via 6-pin header CON3. Then we suggest you test the board to make sure it's working before fitting the LCD panel.

The easiest way to do this is to connect a USB/serial adaptor to CON6 and then open a terminal emulator, set to the default baud rate of 38,400. Make sure the correct COM port for your USB/serial adaptor is selected and then wire up its TX, RX and GND pins to the appropriate pins on CON6, making sure to wire TX to RX and vice versa.

To power the unit, if your USB/serial adaptor has a 5V output, you can wire this to the bottom-most terminal of JP1 (if fitted). Alternatively, fit a jumper to JP1 and plug a mini USB cable from your PC to CON2.

As soon as the unit has powered up, you should see the Micromite's banner appear on your terminal emulator. If you don't, disconnect power and re-check your wiring and COM port selection.

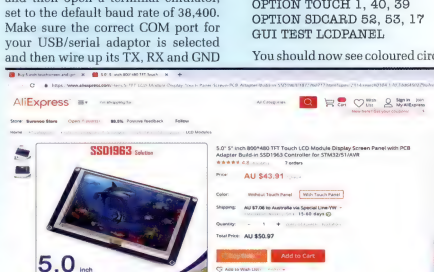
Typical power consumption for the Explore 100 sans screen is around 100mA (at 5V). If yours is significantly under or over this, something is wrong, so check the PCB carefully for soldering defects and misplaced components.

Assuming you've had success, remove power and plug the LCD screen into CON10, attaching it with four 12mm tapped spacers and eight machine screws.

You will then need to power it up and run the following commands on the console, to set up and test the LCD. Power consumption should jump to several hundred milliamps.

```
OPTION LCDPANEL SSD1963_5,
    LANDSCAPE, 48
OPTION TOUCH 1, 40, 39
OPTION SDCARD 52, 53, 17
GUI TEST LCDPANEL
```

You should now see coloured circles



As an example, here's one source of 5-inch LCD Touchscreens we found on AliExpress. They're also available on ebay and from several other suppliers.

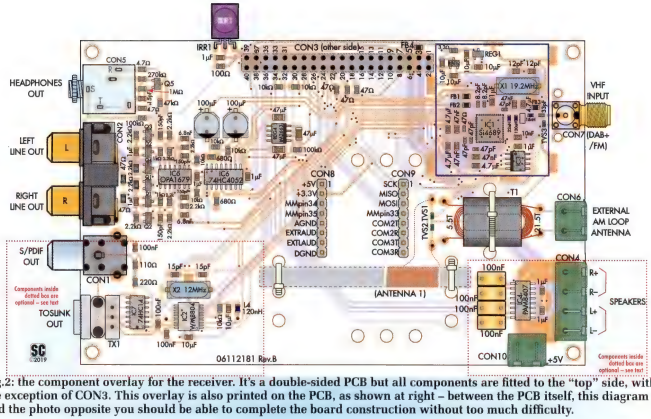


Fig.2: the component overlay for the receiver. It's a double-sided PCB but all components are fitted to the "top" side, with the exception of CON3. This overlay is also printed on the PCB, as shown at right – between the PCB itself, this diagram and the photo opposite you should be able to complete the board construction without too much difficulty.

being drawn on the screen. Press Enter in your terminal emulator to stop, then run this command to calibrate the touch sensor

```
GUI CALIBRATE
```

You will then need to use a thin object that will not scratch the screen, like a toothpick, to carefully press and hold in the centre of the targets which appear in each corner of the screen.

Hopefully, you will get a message on the console that says "Done. No errors".

Otherwise, try calibrating it again. That completes the initial set-up of the Explore 100 module.

Main PCB assembly

Use the main PCB overlay diagram, Fig.2, (and the photo opposite) as a guide to the following assembly steps. The main radio board is built on a double-sided PCB coded 06112181, which measures 134 x 84.5mm (the same size as the Explore 100 module).

The first job is to install IC1, the Si4689 radio IC, which comes in a 48-pad QFN package. If you have purchased a PCB with this chip already fitted then skip to the next section.

There are two reasons why soldering this chip is tricky: the central ground pad on the bottom of the chip, which is inaccessible once it has been placed on the board, and the fact that the other 48 pads on the underside of the chip are barely visible or accessible.

You have two main options for soldering this chip at home: the first is via a hot-air reflow or reflow via direct heating of the PCB with a hotplate. There are other reflow possibilities, such as infrared reflow, but you need expensive, specialised equipment.

All you need to perform the hot-air reflow is an SMD hot air station (which can be purchased for around $50 online), some fresh solder paste and a wooden clothes peg (not plastic!) or similar clamping device.

While it isn't an easy job, it is certainly achievable with some patience.

The second option requires some slightly more expensive and specialised equipment, namely, a temperature-controlled hotplate (such as the type often used for chemistry), however, we have heard stories that a cheap hotplate intended for cooking food could be used.

But that is a bit of a hit-and-miss affair, so we prefer using the scientific hotplate. They can be purchased for a few hundred dollars and you can keep this in your arsenal forever (and you'd better believe SMDs requiring this type of equipment will only become "the norm" in future).

The main advantage of the hotplate method is that the alignment of the chip is not critical; solder surface tension will pull it into the correct position as long as it is reasonably close.

However, that is not generally possible when using hot air because the airflow tends to blow the chip out of position unless it is clamped down.

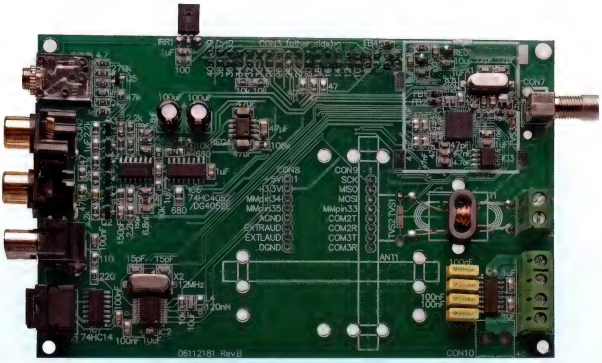
The preparation for both methods is similar. Start by applying a very thin smear of solder paste along all the 48 small pads on the PCB, as well as a thin smear in the middle of the central pad.

By the way, you should use solder-paste that comes in a syringe (ie with a plunger). But you shouldn't use lead-free solder paste as its melting point is too high and you risk damaging either the PCB or components or both!

If you apply too much solder paste at this stage, you will have a lot of excess solder to remove later, so make

Errors in last month's circuit diagram

Some of the connector numbers shown in the circuit diagram (Fig.1) last month were wrong. The two 8-pin expansion headers were labelled CON7 and CON8 but they should be CON8 and CON9. And the auxiliary 5V power connector near IC4 (which is in the lower right-hand corner) should be CON10, not CON9.



This same-size photo shows no ferrite rod antenna fitted – we've found that it picks up a lot of digital noise from the rest of the receiver and therefore is not recommended – you're much better off with an external AM loop antenna if you want to listen to AM. Similarly, no sockets/headers are shown for CON8 or CON9 – these may be used further down the track!

sure you use a minimal amount.

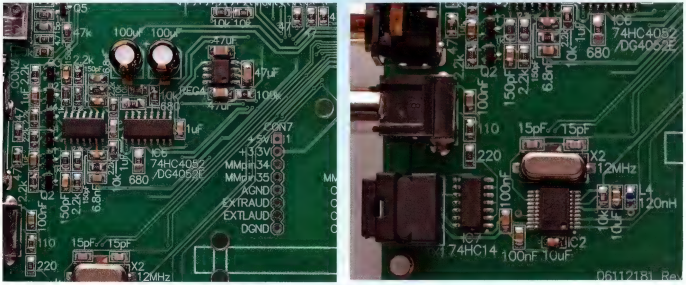
You can't apply solder paste to the 48 pads individually as they're too small. Smearing it along the length of each set of 12 pads is adequate. When it melts, surface tension will pull it off the fibreglass/solder mask and onto the copper pads (and the lands on the bottom of the IC package).

With solder paste applied to the board, drop the IC down in position. Make sure its pin 1 dot is orientated as shown in Fig.2. Using a good light and a magnifier, check the alignment of the lands and the PCB pads. The lands should be just visible from the side of the IC as they "wrap around" the bottom edge slightly.

This step is more critical when using hot air reflow; make sure the lands are accurately aligned on all four sides of the IC and then carefully clamp the chip to the board using a clothes peg (not plastic, or it will melt). Re-check the alignment to ensure it hasn't changed.

For the hot plate method, it's best to get the chip reasonably close to the correct alignment – and you definitely need to get the pin 1 dot in the right location – but the alignment doesn't have to be exactly right.

Now start heating the board. If using hot air, set the airflow low but not to the minimum and the temperature high (close to maximum). The trick is to keep moving the nozzle; don't let it dwell on one spot on the board or chip too long or it might damage it.



For those without 20/20 vision (and perhaps for those who do!) here are enlargements of two of the sections of the board with closely-spaced SMD components. At left is the area around IC5 & 6, at right IC7 & 2.

Move the hot air around, heating the board area around the chip and also the chip itself, then concentrate more on the chip over time until you see the solder melt and start to re-flow.

Make sure all the solder paste melts to ensure all the joints have been made correctly. You may see a little flux smoke come out from under the IC as the solder paste on the central pad reflows.

The amount of time it takes reflow all the solder will depend on whether you have preheated the board (a good idea if you can) and what type of solder paste you are using.

Remove the heat and let the board cool down.

If using a hot plate, you basically just ramp up the temperature of the board and chip together until the solder melts. It should all melt more or less at once. Make sure the hot plate is level and don't bump it.

When the solder paste does melt, you should see the chip move slightly as surface tension pulls it into perfect alignment. Switch off the hot plate and let the board cool down.

Regardless of the method you used, clean off any excess flux using an alcohol solution or specialised flux remover and then carefully examine the edges of the chip under magnification.

Make sure that there is no solder bridging the lands on the outside edge of the chip.

If there is, add some flux paste and carefully use fine solder wick and a regular iron to remove it.

Then clean off the flux paste and re-examine the chip, repeating until you are happy that there are no solder bridges.

Soldering the parts around IC1

These parts are smaller than most of the others on the board and their proximity to IC1 and each other (necessary for good RF performance) makes fitting them a little tricky.

But with a steady hand, they are not too difficult to solder. If your board came with these parts already fitted, skip this section.

Start with the 12 smaller components surrounding IC1. These are in metric 1608 (imperial 0603) size packages, which measure 1.6 x 0.8mm. There are seven capacitors, three inductors, one resistor and a TVS.

Since these components are so small, it's best to handle them with very fine-tipped tweezers. But be especially careful when picking them up since if you drop them (or they flick out of the tweezer tips). Murphy's law almost guarantees you will not be able to find them!

The capacitors and resistors are the easiest. You can place a small amount of solder on one of the pads, slide the part into place while heating it, then solder the opposite end.

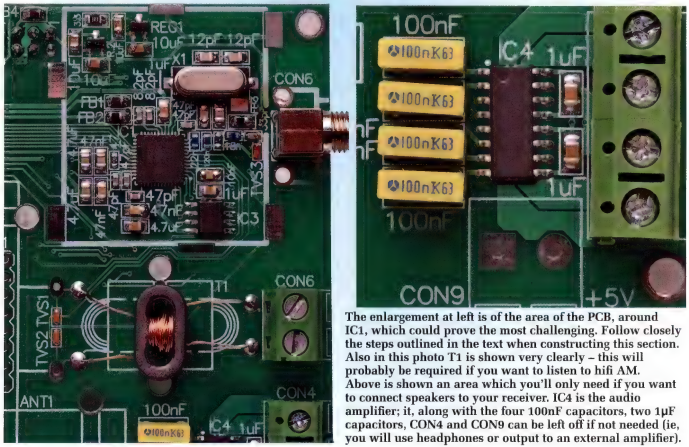
It's then a good idea to wait a few seconds or so for the solder to solidify, add a little flux paste on top of the original solder joint and re-heat it to ensure that both ends are soldered properly.

The inductors are more tricky because the ones we used can only be soldered if they are the right way up; it's easy to put them on the board upside-down and then they will not take any solder.

The trick is to make sure the blue side of the inductors is facing up before soldering them – see the close-up photo (below left) to see how ours were mounted.

Once you have them orientated correctly, you can solder them in the same manner as the capacitors and resistors.

For the small components, that just leaves the TVS, which is similar in construction to the inductors. Its orange side faces up (also visible in the close-up photo).



The enlargement at left is of the area of the PCB, around IC1, which could prove the most challenging. Follow closely the steps outlined in the text when constructing this section. Also in this photo T1 is shown very clearly – this will probably be required if you want to listen to hifi AM. Above is shown an area which you'll only need if you want to connect speakers to your receiver. IC4 is the audio amplifier; it, along with the four 100nF capacitors, two 1µF capacitors, CON4 and CON9 can be left off if not needed (ie, you will use headphones or output to an external amplifier).

Parts list – DAB+/FM/AM Radio Receiver

1 Micromite Plus Explore 100 module with 5-inch touchscreen (see September & October 2016 issues)
[Silicon Chip Online Shop short form kit (no LCD) Cat SC3834]
1 USB Type-A to Mini-B cable or USB/serial adaptor [eg, Silicon Chip Online Shop Cat SC3437]
1 double-sided PCB, code 06112181, 134 x 84.5mm
1 extendable VHF whip antenna with SMA connector [Silicon Chip Online Shop Cat SC4847]
1 AM loop antenna (Jaycar Cat LT3001)
1 small ferrite rod antenna (optional; not recommended) [Jaycar LF1020]
3 small Nylon cable ties
1 22nH 0603 low-loss inductor (L1) [Murata LQW18AN22NG00D]
2 120nH 0603 low-loss inductors (L2,L4) [Murata LQW18ANR12G8ZD]
1 18nH 0603 low-loss inductor (L3) [Murata LQW18AN18NG00D]
4 0603 ferrite beads (FB1-FB4) [Taiyo Yuden BK1608LL680-T]
1 small ferrite balun core (T1) [Jaycar LF1222]
1 1m length 0.25mm diameter enamelled copper wire (T1) [Jaycar WW4012]
1 19.2MHz crystal, HC49-US (SMD), 18pF load capacitance [TXC 9C-19.200MAAJ-T, Digi-Key 887-1062-1-ND] (X1)
1 12MHz crystal, HC49-US (SMD), 18pF load capacitance [TXC 9C-12.000MEEJ-T, Digi-Key 887-1268-1-ND] (X2)
3 XGD10603NR SMD polymer transient voltage suppressors (TVS1-TVS3)
1 black switched PCB-mount RCA socket (CON1)
1 horizontal PCB-mount white/red RCA socket pair (CON2) [eg, Digi-Key RCJ-2112-ND]
1 20x2 female header socket (CON3)
1 20x2 long pin female header socket [Jaycar Cat HM3228]
1 4-way pluggable terminal block and socket, 5/5.08mm pin spacing (CON4)
1 3.5mm stereo switched PCB-mount jack socket (CON5)
1 2-way pluggable terminal block and socket, 5/5.08mm pin spacing (CON6)
1 PCB-mount right-angle SMA socket (CON7) ***OR***
1 PCB-mount right-angle PAL socket (CON7)
[Silicon Chip Online Shop Cat SC4848]
2 8-pin female sockets (CON8,CON9)
1 2-way mini terminal block (CON10; optional)
1 8Mbit TOSLINK transmitter [Altronics Z1601] (TX1)
1 infrared receiver (IRR1)

Case and assembly hardware
1 set of case pieces laser-cut from 3mm clear acrylic [Silicon Chip Online Shop Cat SC4849]
4 M3 x 25mm panhead machine screws
4 M3 x 32mm panhead machine screws
4 M3 Nylon hex nuts
4 9mm long M3 tapped Nylon spacers
4 12mm long M3 tapped Nylon spacers
8 15mm long M3 tapped Nylon spacers

Semiconductors
1 Si4689 digital radio IC, QFN-48 (IC1) [Digi-Key 336-4159-ND]
1 WM8804 digital audio transceiver, SSOP-20 (IC2)
1 AT25SF321 32Mbit 104MHz serial flash, SOIC-8 (IC3)
1 PAM8407 stereo 5V amplifier IC, SOIC-16 (IC4)
1 OPA1679IDR quad rail-to-rail op amp, SOIC-14 (IC5)
1 74HC4052 dual 4-channel analog multiplexer, SOIC-16 (IC6)
1 74HC14 hex schmitt trigger inverter, SOIC-14 (IC7)
2 MCP1700T-1802E/TT 1.8V LDO regulators, SOT-23 (REG1,REG2)
1 LM2663MX switched capacitor voltage inverter, SOIC-8 (REG4)
2 BC817 PNP transistors, SOT-23 (Q1,Q3)
3 BC807 NPN transistors, SOT-23 (Q2,Q4,Q5)
2 BAV99 dual series diodes, SOT-23 (D1,D2)

Capacitors
2 100µF 6.3V electrolytic (through-hole or SMD)
3 47µF X5R 1206
6 10µF X5R 0805
7 4.7µF X5R 0805
9 1µF X7R 0805
4 100nF MKT
3 100nF X7R 0805
4 47nF NP0 0805
1 10nF X7R 0805
2 6.8nF NP0 0805
4 150pF NP0 0805
4 47pF NP0 0603, low-ESL [Johanson 251R14S470GV4T]
1 33pF NP0 0603, low-ESL [Johanson 251R14S330JV4T]
3 15pF NP0 0805
2 12pF NP0 0805
2 8.2pF NP0 0603, low-ESL [Johanson 251R14S8R2CV4T]

Resistors (all 1% SMD 0805 apart from one 47Ω)
1 1MΩ 1 270kΩ 2 100kΩ 1 47kΩ 7 10kΩ 10 2.2kΩ
2 1kΩ 2 680Ω 1 220Ω 1 110Ω 1 100Ω 5 47Ω
1 47Ω (0603) 2 4.7Ω 1 3.3Ω

Sourcing the critical Si4689 radio receiver IC

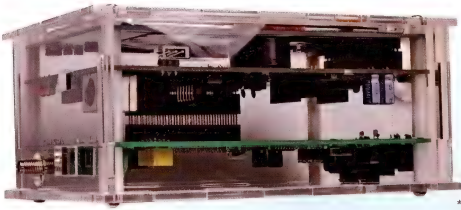
One of the reasons we chose the Si4689 over some of the other Silicon Labs chips (eg, the slightly cheaper Si4685) was, at the time, due to its better availability. Over the months we have been working on this design, Digi-Key has consistently had several hundred in stock.

But some time in late December, their stock level dropped very low. We purchased the last remaining parts in stock to ensure that we could supply at least some pre-populated PCB.

The manufacturer's lead time on this component is not particularly long (around six weeks) and we have already requested that some of the next delivery be sent to us for fitment to our radio boards.

Hopefully, by the time this article appears, the stock situation will have improved and Digi-Key will have some chips in stock, ready to order. If you want to mount this chip yourself but find that it is out of stock, we suggest that you order it anyway.

As far as we can tell, you should receive it within a few weeks.



The completed receiver, housed in its custom-designed acrylic case*. The upper PCB is the Micromite Plus Explore 100 board with its colour touch screen plugged in; the DAB+/FM/AM radio receiver PCB is the green-edged board at the bottom. It too connects directly to the Explore 100 via a multi-way header plug and socket. There are very few external connections – visible are the external DAB+/FM antenna socket and the connectors for an AM loop antenna and audio (speaker) output. The opposite end has the stereo audio, headphones, S/PDIF and TOSlink outputs.

Available from the SILICON CHIP ONLINE SHOP

Now you can move on to the larger components around IC1. There are three ferrite beads and 11 larger capacitors immediately surrounding it. These can be soldered using the same basic technique.

The only difference is that it's easier since the components are much larger and easier to see.

Remaining components near IC1

In terms of the components surrounding IC1, except for the VHF input connector (CON6), which we'll leave until later, all that remains is regulators REG1 & REG2, crystal X1, flash memory chip IC3 and seven associated passive components, comprising six capacitors and one 3.3Ω resistor.

It's best to start with REG1 and REG2, both 1.8V regulators. These can be soldered similarly to the passives, by tacking the central pin, checking that the other two pins are lined up over their pads, soldering them, then refreshing the first solder joint with a dab of flux paste.

Then you can fit the remaining resistor and capacitors mentioned above.

Finally, solder flash chip IC3 in place, ensuring that its pin 1 notch or dot faces the top of the board, as shown in Fig.2.

The pins are relatively widely spaced so you can solder them individually. If you accidentally get a solder bridge between adjacent pins, clean it up with some flux paste and solder wick.

Now solder 19.2MHz crystal X1 in place. It is not polarised, so its orientation is not critical.

It is a two-pin device; the third pad underneath it which it partially overlaps is provided to allow for grounding the crystal case. But we have not found that to be necessary.

Building outside the box

Having completed the critical radio receiver section, move on to the remaining components on the board.

There are a couple of optional sections so you will need to decide whether to fit them.

IC4 and the components that surround it, in the lower-right corner of the board, are only needed if you plan to drive an external speaker or speakers directly from the unit.

These are shown inside a dotted box on Fig.2.

IC2, IC7 and X2 at lower left, plus the nearby passives and connector CON1 and optical transmitter TX1 are only needed if you require a digital audio output. These are also shown inside a dotted box on Fig.2.

As we said last month, the Si4689 firmware does not appear to support digital audio output in DAB+ mode so keep that in mind.

Having decided which components to fit, start by soldering the remaining ICs in place.

If you are fitting IC2 (WM8804), do that next as it's in a fine-pitched SSOP package. The remaining ICs are much easier to solder.

For IC2, the simplest technique is to spread a thin smear of flux paste on all of its pads, then tack down one corner pin and check that all the other pins are aligned with their pads. Also make sure that its pin 1 dot is facing towards the bottom of the board, as shown in Fig.2.

Once you've verified that, tack solder the opposite corner pin in place, then load some solder onto the iron and gently drag it along the edge of the pads on one side of the chip. The flux should cause the solder to wick along the pad and onto the pin, forming perfect joints.

Repeat on the other side. Add extra solder to any pins which do not appear to have a good fillet and use flux paste and solder wick to carefully clean up any bridges.

Proceed to solder IC4-IC7 and REG4, all in larger SOIC packages, using either a similar technique or soldering each pin individually.

Once again, with all these chips, take care to ensure that the pin 1 dot or notch is orientated as shown in Fig.2. If your chip lacks both markings, check for a bevelled edge. This will indicate the pin 1 side of the chip.

Transistors and diodes

Now mount diodes D1-D2 and transistors Q1-Q5, all in SOT-23 packages and all in the upper-left corner of the PCB. D1 and D2 are identical but Q1-Q5 consist of two different types so don't get them mixed up.

Once that's done, solder the remaining SMD passive components (mainly resistors and capacitors) in place where shown in Fig.2. That also includes the remaining ferrite bead, FB4, near the top edge of the board and SMD inductor, L4, which goes to the right of IC2 and may be left off if you are not fitting IC2.

Now is a good time to fit transient voltage suppressors TVS1 & TVS2, just to the left of where transformer T1 will go later.

Use the same technique as before, again with the orange side mounted facing up. 12MHz crystal X2 can then be soldered in place. It is not needed if IC2 has not been installed.

Winding the transformer

The Si4689's AM antenna input is impedance-matched to a ferrite rod antenna, which has a typical inductance of around 180-450μH. A loop

antenna has much better performance (and can be mounted away from sources of interference) but typically has a lower inductance, around 10-20µH, due to the lack of a ferrite core. So a matching transformer is required for the AM loop antenna.

This can be easily wound on a small ferrite balun core (see parts list) using 0.25mm diameter enamelled copper wire.

Cut a 500mm length of this wire and then wind 21.5 turns onto the balun core, leaving 25mm free at the start. The end of the winding should come out on the same side of the balun but out from the other hole.

Trim the longer end to the same length and then strip the enamel off both ends. Make a mark on the end of the core so you know which end has the terminations for the larger winding.

Now cut a 200mm length of that same wire and wind five and a half turns onto the same core, starting from the opposite end. Again, leave 25mm spare at the start and cut the end to the same length. Strip the insulation from those wires, too. Your transformer is complete and ready to be mounted.

Note that our prototype transformer was wound with the terminations all at one end. This works as well but makes it harder to mount. And it's easier to get the windings mixed up.

Through-hole components

Start by fitting the two 100µF electrolytic capacitors, with the longer (positive) leads through the holes towards the top edge of the board, as shown in Fig.2.

Surface-mounting electrolytic capacitors can also be used.

Next, fit the four 100nF MKT capacitors at lower right, assuming that you have already fitted IC4. These are not polarised.

You can now mount your transformer (T1) to the board using a cable tie, with the 21.5 turn winding (marked earlier) towards TVS1 and TVS2. Pull the cable tie tight and cut off the excess, then solder the four wires in place where shown.

CON4 and CON6 are pluggable terminal blocks so solder them in place now, with the socket side sticking out over the side of the PCB.

Two-way horizontal RCA connector CON2 will probably have a triangular mounting bracket on the top, which we don't need. It will get in the way of the case later, so we suggest that you cut it off with a hacksaw (flush with the top of the rectangular socket moulding) and then file the top smooth.

You can then push the socket down onto the PCB fully and solder its four pins in place.

Next, install jack socket CON5, making sure that it is aligned with the edge of the PCB – you may need to twist it a little to get it lined up. Remove the nut from its shaft before soldering it in place. Now is also a good time to install the single RCA socket (CON1) and TOSLINK transmitter (TX1), if you have fitted IC2.

Now fit SMA socket CON7. It's just a matter of pushing it all the way down onto the PCB, with the barrel projecting out over the edge, and soldering the five pins. But note that the body of the connector is a large piece of metal and it has large pins, so you will need a hot iron to form satisfactory solder joints.

You could use a PAL socket but these are hard to source, and these days more and more antennas are using F-type or SMA connectors instead. We have added some PCB-mounting PAL connectors to our online shop (see the parts list), so you can purchase one of those and fit it to the board instead of the SMA connector if you prefer to do so.

Note that if you do this you will need to enlarge the corresponding hole in the case when the time comes to assemble it.

The two eight-pin female headers (CON8 & CON9) are for possible future expansion. You can solder them in place now, or you can leave them off until we publish details of a future expansion board which will plug into those sockets and mount them then.

CON10 is an optional two-way terminal block which connects directly to the 5V supply for the audio amplifier IC (IC4). We've designed the board so that 5V power is supplied to it via the Explore 100.

But since the audio amplifier can draw significant current, and that current must flow through a single pin on the 40-way header, to get maximum power from the speaker outputs, you should feed the 5V supply in via CON10 instead. If you plan to use that option, fit the CON10 terminal block now and then you can wire it up to a chassis socket later.

Solder the infrared receiver, IRR1, with its leads bent so that it sticks out the top edge of the board, as shown in Fig.2. Make sure that its lens bump faces away from you, when looking at the board as shown in the overlay diagram. If you're unsure, check our photos.

Bend the leads so that the bottom of the receiver package is just about resting on the edge of the board.

The last component to mount on the board is the two-row 40-pin header socket. We've left it until last because it mounts on the back of the board. Make sure it's sitting flush on the PCB and solder all 40 pins, taking care not to apply too much heat, which could deform the plastic.

You will notice that we have not mentioned fitting the ferrite rod antenna. You can do so if you wish; it's shown dotted on the overlay diagram in the correct (horizontal) position. You then just need to connect the wires with green and red markings to the pads shown.

The reason we have left it out is that we've found that it picks up a lot of digital noise from the control circuitry and as a result, AM reception performance with the ferrite rod is not good. If you connect an AM loop antenna without the ferrite rod in place, you will get much better AM reception than if the ferrite rod is mounted on the board.

We are currently experimenting with possible shielding solutions and also software changes to mitigate this interference issue and if we come up with a good solution, it will be incorporated into the construction process in next months' issue.

But for now, the safest thing to do is leave the ferrite rod off the board. You can always fit it later. It's held in place using two cable ties which loop through holes on the PCB, as shown in Fig.2.

Coming next month

You should now have a fully assembled and working Explore 100 module plus a completed radio PCB.

Next month we will have the details on how to put them together, build the case, load the software, test it and get it up and running. We'll also have more screen grabs and details on how to use the radio. SC

Philips Brilliance 499PH1 Curved, UltraWide, 49-inch monitor

Review by Nicholas Vinen

This monitor is unlike anything we have seen before. A typical monitor is about twice as wide as it is tall. This one has an aspect ratio of 32:9, meaning that it's about three and a half times as wide as it is tall! It's also concave, as you can see from the photos. While that might seem strange, once you get used to it, it's actually really good.

You may recall that we previously reviewed two Philips 4K monitors, a 40-inch (100cm) set in the September 2015 issue (siliconchip.com.au/Article/9003) and a 43-inch (109cm) set in the March 2017 issue (siliconchip.com.au/Article/10572).

I liked the 40-inch 4K monitor so much I purchased one – in fact, I am still using it as my primary screen and I am quite happy with it. The 43-inch monitor we reviewed later is even better and I've just recently ordered one of those.

There are many reasons why I like these large, high-resolution monitors. At home, I have two high-resolution 30-inch monitors side-by-side. But a single, larger monitor is better for jobs like PCB layout, where you want to expand one piece of software to fill up all your screen real estate.

That lets you see the whole circuit board with all the details in one glance. You don't have to zoom and pan around; you just use your eyeballs.

It's a very natural way to work. You can do it with multiple monitors but the section you're interested in always seems to be in the gap where the bezels meet. It is very annoying.

But two slightly smaller monitors will have a greater total area, so that set-up can be better when you are using two applications at the same time. I do that frequently; for example, I might write or edit an article on one monitor while viewing PDF data sheets, circuit diagrams, component data on supply websites and other reference material on the other monitor.

So clearly, both configurations are

excellent but for different reasons.

Enter the challenger

This time, rather than reviewing yet another huge monitor, we thought we would look at something a bit different.

And we certainly found something very different when Philips Monitors Australia dropped off this weird looking beast into our office for review.

It's 1.2m wide and 370mm tall, with a native resolution of 5120 x 1440 pixels (called "DQHD" or "5K"). That's around 7.4 megapixels, compared to around 8.3 megapixels for a 4K display. Its total screen area is very similar to that of a 40-inch 4K monitor, at just under half a square metre.

It comes with a heavy height-adjustable, swivelling and tilting stand, necessary to keep it from toppling over if you give it a bump. This is one of the best monitor stands we've used; the adjustment range is wide and adjustments are smooth.

It also has an integrated webcam and USB-C support, which opens up some intriguing possibilities that we'll come to later. It has quite a few useful features available via its on-screen interface, which are described below.

Daily use

The real question with this monitor is whether it's better than a more traditional large monitor, such as the two 4K displays mentioned above. The answer is that it depends on what you are doing with it.

You can think of this screen as if it is two 27-inch, 2560 x 1440 pixel

These two shots, from the side and from above, give an excellent idea of the amount of curvature of the display. It takes arguably a couple of hours to get used to but then it is a real bonus!

monitors side-by-side on your desk. The main difference is that you don't have the annoying bezels running down the middle of the two screens. You can bring up two applications side-by-side, in which case, it's just like having two separate monitors. But you can still run a single large program seamlessly.

So it definitely has greater flexibility than two separate displays – except for the fact that with separate displays, you can rotate one or both into portrait mode. But in practice, we found in the past that we rarely did, even when we had monitors that allowed it, as it was too much of a hassle.

I think the primary purpose of a monitor like this is for playing 3D games. They will definitely benefit from the ultra-wide aspect (which sort of mimics the field of human vision, although it should be a bit taller in my opinion). I have played games on dual monitors setups before and while you do eventually get used to the bezel in the middle, it's much better without it.

But I expect many of our readers are more interested in using their computer for ECAD tasks than games, so it's a fair question to ask how well it works for drawing circuit diagrams and laying out PCBs.

The answer is that it does work well for those sorts of jobs, but not quite as well as the 43-inch 4K Philips BDM4350UC that we reviewed previously.

On the other hand, this new 499P monitor is probably better overall for other tasks such as web browsing, e-mail, word processing and viewing PDFs. That's because it's better suited for use with side-by-side application windows.

It allows a display set-up that I've never really used before, too, with three different programs arrayed side-by-side, each taking up about 1/3 of the screen. When you do that, each window is approximately square, and of course, the middle one is centred in the display, right in front of your eyes.

It's a pretty good way to work and something that I think I would find myself using more and more if I keep this monitor long-term.

Other aspects of the display

I can't fault this display on sharpness or colour accuracy. The latter is especially good. It's way better than on my older 40-inch Philips BDM4065UC, which sometimes displays light colours with a completely incorrect hue, despite being in a semi-calibrated sRGB mode (the 43-inch BDM4350UC we reviewed later was a lot better in that respect).

It's also very bright. On maximum brightness, it's probably TOO bright, at least in a typical office environment. But that's a good thing in case you need to use it in a more brightly lit room, or you need more contrast. The backlighting is via LEDs, as is common these days, which is part of the reason for the very even brightness and excellent colour rendition.

Philips refers to this monitor as having "Ultra Wide-Color Technology" which means that it can reproduce the entire RGB colour space and more. It has 117.3% of the sRGB colour gamut so it should satisfy all but the pickiest photographers and digital artists.

As for the curvature, I found it pretty odd at first but quickly got used to it. If a monitor this wide was flat, you would have a few problems because the edges and corners are so much further away from your eyes than the centre. That would mean that the viewing angle would be quite significant at the edges.

And while this monitor's performance is not bad off-axis, it doesn't have the best viewing angle I've ever seen; it starts "washing out" once you are more than about 30-40° off-axis. That's because it's an MVA type panel (multi-domain vertical alignment), which does not have quite as good a viewing angle as an IPS (in-plane switching) LCD panel.

The curvature helps to make the viewing angle pretty much consistent across the display, so that you don't notice that during normal usage.

Also note that with a wide, flat monitor, the edges would look a bit distorted because the pixels are further away and therefore appear smaller compared to those in the middle. The curvature helps with that, too, as the edges are closer to your eyes than the would be on a flat monitor.

One caveat, though, is that since the curvature is fixed, that means the ideal viewing distance is fixed. And it's a little further away from the monitor than I am used to, or would prefer. That's because, at the ideal viewing distance, it does not fill my field of vision.

I'm probably nit-picking here; it isn't that bad, but I would have preferred more curvature, to allow me to get my head closer to the display while still retaining the advantages conveyed by the curvature. But perhaps a monitor that curved would be impractical to manufacture. Again, this is something that I am starting to get used to.

By the way, there is an advantage to the MVA type panel over IPS: increased contrast with deeper and more consistent blacks. And you can certainly notice it on the 499P; its contrast and the blacks on this monitor are excellent.

Interestingly, the monitor reports its native resolution to the PC as 3840 x 1080, even though it actually has 5120 x 1440 pixels. We suspect that this is

Specifications

Picture/Display
- LCD panel type: VA LCD
- Backlight type: W-LED system
- Panel Size: 48.8 inch / 124 cm
- Display Screen Coating: Anti-Glare, 2H, Haze 25%
- Effective viewing area: 1193.5 (H) x 335.7 (V) mm at a 1800R curvature*
- Aspect ratio: 32:9
- Optimum resolution: 5120 x 1440 @ 60Hz
- Pixel Density: 109 PPI
- Response time (typical): 5 ms (Gray to Gray)*
- Brightness: 450 cd/m²
- Contrast ratio (typical): 3000:1
- SmartContrast: 80,000,000:1
- Pixel pitch: 0.233 x 0.233 mm
- Viewing angle: 178° (H) / 178° (V), @ C/R > 10
- Flicker-free
- Picture enhancement: SmartImage
- Display colors: 16.7 M
- Color gamut (typical): NTSC 103%*, sRGB 121%*, Adobe RGB 91%*
- HDR: DisplayHDR 400 certified (DP / HDMI)
- Scanning Frequency: 30 - 230 kHz (H) / 48 - 70 Hz (V); Adaptive sync (for HDMI/DP)
- SmartUniformity: 97 ~ 102%
- Delta E: < 2
- sRGB
- LowBlue Mode
- EasyRead
- Adaptive sync

Connectivity
- Signal Input: DisplayPort 1.4* x 1, HDMI 2.0 b x 2, USB-C 3.1 Gen 2 x 1 (upstream, power delivery up to 65 W)
- HDCP: HDCP 2.2 (HDMI / DP / USB-C)
- USB:: USB 3.1 x 1 (upstream), USB 3.1 x 3 (downstream with x 1 fast charge B.C 1.2)
- Audio (In/Out): Headphone out
- RJ45: Ethernet LAN (10M/100M/1G)
- Sync Input: Separate Sync, Sync on Green

USB-C docking
- USB-C: Reversible plug connector
- Super speed: Data and Video transfer
- DP: Built-in Display Port Alt mode
- Power Delivery: USB PD version 2.0
- Max power delivery: Up to 65W (5V/3A; 9V/3A; 10V/3A;12V/3A; 15V/3A; 20V/3.25A)

Convenience
- Built-in Speakers: 5 W x 2
- Built-in webcam: 2.0 megapixel FHD camera with microphone and LED indictor (for Windows 10 Hello)
- MultiView: PBP (2x devices)
- User convenience: SmartImage, Input, User, Menu, Power On/Off
- Control software: SmartControl
- OSD Languages: Brazil Portuguese, Czech, Dutch, English, Finnish, French, German, Greek, Hungarian, Italian, Japanese, Korean, Polish, Portuguese, Russian, Simplified Chinese, Spanish, Swedish, Traditional Chinese, Turkish, Ukranian
- Other convenience: Kensington lock, VESA mount (100x100mm)
- Plug & Play Compatibility: DDC/CI, Mac OS X, sRGB, Windows 10 / 8.1 / 8 / 7

Stand
- Height adjustment: 130 mm
- Swivel: -/+ 20 degree
- Tilt: -5~10 degree

Power
- ECO mode: 43.3 W (typ.)
- On mode: 45 W (typ.) (EnergyStar 7.0 test method)
- Standby mode: 0.3 W (typ.)
- Off mode: Zero watts with Zero switch
- Power LED indicator: Operation - White, Standby mode- White (blinking)
- Power supply: Built-in, 100-240VAC, 50-60Hz

Dimensions
- Product with stand(max height): 1194 x 568 x 303 mm
- Product without stand (mm): 1194 x 369 x 156 mm
- Packaging in mm (WxHxD): 1308 x 384 x 553 mm

Weight
- Product with stand (kg): 15.30 kg
- Product without stand (kg): 11.00 kg
- Product with packaging (kg): 21.48 kg

Operating conditions
- Temperature range (operation): 0°C to 40°C °C
- Temperature range (storage): -20°C to 60°C °C
- Relative humidity: 20%-80 %
- Altitude: Operation: +12,000ft (3,658m), Non-operation: +40,000ft (12,192m)
- MTBF (demonstrated): 70,000 hrs (excluded backlight)

Sustainability
- Environmental and energy: EnergyStar 7.0, EPEAT*, RoHS, WEEE, TCO certified
- Recyclable packaging material: 100 %
- Post consumer recycled plastic: 85%
- Specific Substances: PVC / BFR free housing, Mercury free, Lead free

Compliance and standards
- Regulatory Approvals: CB, CE Mark, FCC Class B, SEMKO, cETLus, CU-EAC, TUV Ergo, TUV/GS, EPA, ICES-003, MEPS, RCM, PC-Recycle

Cabinet
- Front bezel: Black
- Rear cover: Black
- Foot: Black
- Finish: Texture

Accessories
- Included Accessories: Philips RC6 remote control

because a lot of devices cannot handle the higher resolution. Those that do support it can generally be forced into the monitor's native resolution.

This monitor supports a 120Hz refresh rate, which would be great for games, but we suspect that it's only possible at the 3840 x 1080 resolution. It's far less critical to run the monitor at its native resolution for games since you won't notice the slight resulting softness, and it's less work for the graphics processing unit (GPU), so you will likely get a higher frame rate too.

The very fast display update rate (5ms grey to grey) is also what you want for playing games, to minimise "ghosting" of fast-moving objects across the screen.

Unlike some cheaper monitors, the 499P has a proper anti-glare coating. I think that's important since glossy monitors tend to reflect what's behind them and it can make them very hard to view in brightly lit areas.

One small disadvantage of the curved screen, though, is that it's harder to adjust the monitor's angle to avoid glare, compared to a flat screen which only reflects light at one angle. But the anti-glare coating certainly helps to reduce the severity of any light which may be reflected.

Additional features

I am using a DisplayPort cable from my video card to the monitor, to allow me to run it at full resolution with a 60Hz refresh rate. It was basically "plug-and-play"; I spent a few minutes going through the graphics settings on my PC and the monitor's menus but it worked straight away.

It also has two HDMI inputs but unless you have a very new video card which supports HDMI 2.0, you probably won't be able to run it at its native resolution with a decent refresh rate that way.

One of the neat features of this monitor (and many other Philips monitors) is that you can split the monitor in half and show the display from one input on one half, and another input on the other half.

So if you had a video card capable of driving two 2560 x 1440 monitors via two separate outputs, but not a single 5160 x 1440 monitor on one output, you could still run the monitor at its native resolution. From the computer's point of view, it's two separate monitors.

Or you could connect two different computers and have the display from each shown simultaneously.

The menu system of this monitor is easier to use than that of the 40-inch and 43-inch monitors mentioned above since the control buttons are arrayed along the bottom edge, rather than it having a joystick hidden behind the screen.

USB C support

There is actually a fourth display input and that is via a USB C port. Yes, video can be transmitted on a USB C cable, along with data and power.

One of the neat aspects of this is that if you have a laptop or notebook with a USB C port, you only have to plug in a single cable to use the monitor and it will also connect your USB peripherals AND charge the battery at up to 60W.

That's extremely handy!

We tested this feature out with a Macbook lent to us by Philips Monitors for testing purposes and found that it was indeed just a matter of plugging the USB C micro cable in at both ends and no further configuration was necessary.

However, we were unable to use the monitor at full resolution in this manner; it dropped to 3840 x 1080. We suspect this is a USB C video limitation. It's a pity since while the monitor is usable at this resolution, it's a bit fuzzy. You really want to run it at its native resolution.

Still, the all-in-one connectivity offered by USB C is excellent and something that we hope will become more widespread in future.

Like most monitors, this one has a built-in USB hub which also incorporates standard full-size ports in addition to the USB C micro port that we used to test the above features. So even if your computer doesn't support USB C, you can still connect your keyboard and mouse (or whatever) via its hub, so you only need one USB cable running back to the PC.

The various inputs, USB sockets and power connector are arranged along the bottom of the monitor which makes it a bit fiddly to plug them in but it is a bit tidier than having cables that plug into the back of the monitor. However, while the real benefit of sockets on the bottom should be that you can push the monitor's back up against a wall or other object, the stand doesn't allow you to do that.

CAUTION: CHILDREN ABOUT!

We mentioned it briefly in the text but with any large flat screen monitor, you have to be extremely careful if you have young children about.

There have been several reports of children tipping the monitor over on themselves, resulting in serious injury – and worse. These things are heavy!

Conclusion

I've been using the Philips Brilliance 499P monitor for a variety of tasks for a couple of days and I've come to like it a great deal. I am planning on buying a new monitor soon and will be considering this one, along with the 43-inch, 4K BDM4350UC. Which is better depends on what you are planning to do with it.

If you're into gaming at all, or you're mainly going to use it for web browsing, e-mail, word processing or even programming, the widescreen 499P has a lot going for it. It's just a bit more flexible in terms of multi-window layouts and lends itself better to having several applications open at a time.

But if you do a lot of photo editing, PCB layouts, drawing large and complex diagrams or other work where a single colossal window is what you want, a large 4K monitor with a more traditional aspect ratio such as the BDM4350UC is probably better.

By the way, the BDM4350UC will likely be replaced with a newer model during 2019. We expect that its replacement will be even better, based on our experience with the 499P.

Having said that, it's hard to go past the 499P for the "wow" factor. Pretty much everyone who's seen it while I've been working on this review has commented on it!

I would strongly recommend both of those Philips monitors as I feel that they are both excellent value for money.

The UltraWide 499P has an MSRP $1999 but you can expect to pay a little less "on the street".

The monitor is expected to be available by early this month. Contact your favourite computer store to find out when they will be available for purchase. SC

IPC Member

EMS Since 1999

LEACH

Reliable partner for electronic contract manufacturing

ElectroneX *Meet us: Stand D16*
11~12 September 2019
Melbourne Convention and Exhibition Centre (MCEC)

FLEXIBLE PRODUCTION

- Small to medium batch order processing
- Flexible production with prompt responding

HIGH-MIX ENGINEERING

- Programming, testing, repairing

DFM IMPROVING

- Help improve manufactura -bility from design period
- Lower production cost, More reliable circuit boards

SUPPLY-CHAIN MANAGEMENT

- Components global sourcing and procurement
- Global logistics delivering goods around the world

LEACH (HK) Co., Ltd **Electronic Contract Manufacturing Turnkey Solution**
LEACH (SZ) Co., Ltd ✉ info@leach-pcba.com 🌐 www.leach-pcba.com

VINTAGE WORKBENCH

By Ian Batty

BWD's 216A hybrid bench supply

BWD was a major Australian electronics manufacturer from their founding in 1955 through to the 1980s and this hybrid (valve/solid state) power supply is from their golden era. The BWD 216A delivers 0-400V at 0-200mA and 0-250V at up to 50mA and has two 6.3VAC unregulated outputs. It was marketed as a general purpose laboratory power supply.

I recently purchased a BWD 216A power supply, which was originally released in the early 70s. I consider it a smart design; the way the circuit operates is quite intriguing. This unit had high quality construction and was a commercial success, selling over 40,000 units.

If you haven't heard of BWD, they were a famous Australian electronic test instrument manufacturer for many years. See the history panel for some details on the company.

BWD is still around in the same location at Mulgrave, Victoria, even to today. Over time, they have undergone multiple name changes, and are now called Observator Instruments.

While the BWD 216 was released around 1974, it includes five valves as well as numerous transistors and a couple of ICs. Why use valves in a relatively recent design? The main reason is that at the time, high-voltage, high-power semiconductor devices were not really available. Valves fit the bill just fine.

The 216A has two regulated outputs. One output can be varied over the range of 0-400V and supplies up to 200mA with an adjustable current limit, while the other delivers 0-250V at up to 50mA.

The two outputs are separate and floating, so they can be biased up to ±500V DC from Earth and can be "stacked" if necessary, eg, to give split rails.

Both outputs have an impressive regulation to 0.002%+3mV for a 10% line (ie, mains) variation over 100% of the load range. Ripple and noise is specified as <20mV peak-to-peak, 1mV RMS for the 400V output and <10mV peak-to-peak, 1mV RMS for the 250V output.

Recovery time for both outputs is <50µs for a 100% load step, to within 100mV. The 400V output can be used as a constant-current source with a setting between 20mA and 200mA while the 250V output has a fixed current limit of around 60mA.

The unit also has two bonus 6.3VAC

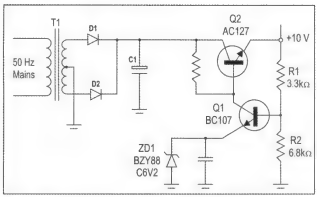


Fig.1 (left): a basic example of a series regulator made with two transistors and a zener diode.

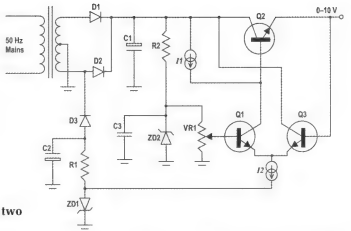


Fig.2 (right): a more complex example of a series regulator, which can be adjusted for a zero output voltage and has improved regulation. It incorporates two constant-current sources (I1/I2) which pass a fixed current regardless of voltage.

outputs each rated at up to 3A.

One of the most impressive aspects of this power supply is that its specifications are still pretty good by today's standards, especially the line and load regulation and ripple/noise figures. And they achieved that almost entirely with discrete parts, many of which would be considered reasonably ho-hum these days.

As this power supply has a fairly involved design, I'm going to start by explaining some of the basic principles of voltage regulation and then expand my description to includes sections of the actual power supply circuit.

BWD 216 versions

The 216 and 216A differ mainly in how they generate the internal supplies to power the differential amplifiers. The 216 used voltage multipliers from 6.3VAC windings to produce the low-voltage comparator supplies while the 216A uses additional, dedicated 30VAC windings.

Series regulation

The 216A uses series regulation, where a variable resistance "pass" element between the mains-derived DC source and the output terminals controls the output voltage.

A negative feedback loop compares the output voltage to the desired voltage and adjusts the resistance of the pass element to maintain the desired output voltage regardless of load variations or current draw.

Practical regulators also sense the load current and increase the resistance of the pass element if an excessive amount of current is being drawn, cutting off the current flow to protect both the load and the regulator from either overload or a short circuit at the output.

By making the overload current limit adjustable, and making the over-current protection part of the linear negative feedback loop, the supply can also be used as a constant-current source.

A basic series regulator can be built with just three semiconductors, as shown in Fig.1: a reference diode (ZD1), pass transistor (Q2) and feedback transistor (Q1). Reference diode ZD1 provides 6.2V at Q1's emitter. Q2's base connects to a voltage divider wired across the output.

Q1 will start conducting when its base voltage reaches around 6.8V (ie, 0.6V above its fixed emitter voltage), which due to the feedback divider of R1 and R2, will happen when the output voltage is around 10V.

If the output voltage rises above 10V, eg, due to a reduction in output loading, this will mean that Q1's base voltage increases, increasing its collector current.

As a result, the voltage at the base of Q2 will drop. Since Q2 is a simple emitter-follower, its emitter voltage (the output voltage) will fall until the circuit re-balances, with the output voltage again around 10V.

Likewise, if the output voltage falls (due to a heavier load), this will lower Q1's base voltage, causing it to conduct less current and allowing the base voltage of Q2 to rise. Q2 will thus deliver more current to the output and bring its voltage back up to 10V.

Of course, such a simple design has limitations, such as the fact that as Q1 and Q2 heat up and cool down, their base-emitter voltages change and so the output voltage will drift. And the output voltage can never be adjusted below 6.8V or else Q1 will never turn on. But it serves as a useful demonstration of the basic principle.

An improved series regulator

The slightly more complex design shown in Fig.2 allows adjustment down to 0V and provides improved regulation.

This diagram includes two "current sources", I1 and I2. These represent devices (or sub-circuits) are able to maintain a fixed current flow regardless of the voltage across the device.

Traditionally, Junction Field Effect Transistors (JFET) were used in this role with a zero gate bias. They are depletion mode devices, so an increased gate bias results in reduced channel current. With zero bias, they tend to act as a current source although the exact current varies considerably from device to device.

This means that JFETs used in this role are typically manually selected from a batch, based on the measured current with zero bias.

By the way, you may have seen "current regulation diodes" for sale. These are JFETs which are batch-selected to fall within a particular current range. The gate terminal is internally connected to the source via a resistor, so it is not exposed, resulting in a two-terminal device that looks like a diode.

The pass element is still labelled Q2. It needs a certain maximum base current to give the maximum output current. A resistor was used to supply this in the simpler version (Fig.1) but it will typically have a value less than

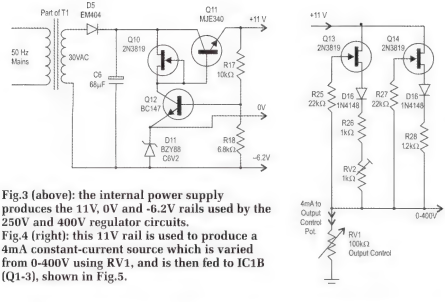


Fig.3 (above): the internal power supply produces the 11V, 0V and -6.2V rails used by the 250V and 400V regulator circuits.
Fig.4 (right): this 11V rail is used to produce a 4mA constant-current source which is varied from 0-400V using RV1, and is then fed to IC1B (Q1-3), shown in Fig.5.

1kΩ. So the voltage gain of Q1 will be low and regulation will be poor.

I1's constant-current characteristic gives it a very high impedance; in theory, it is infinite, though obviously, that is not possible in reality. So Q1's gain is maximised and regulation is improved.

Rather than using a single transistor for negative feedback, in this case, we have two: Q1 and Q3, which form a "long-tailed pair" differential amplifier.

The output voltage is fed back to the base of Q3, the inverting input, while the reference voltage is applied to the base of Q1, the non-inverting input.

This reference voltage is derived from the unfiltered DC supply by zener diode ZD2, via resistor R2 and bypassed by capacitor C3. It is then varied using potentiometer VR1 to provide a voltage between 0V and 10V to the base of Q1, which indicates the desired output voltage.

Because the reference and feedback voltages are applied to two different transistor bases now, the 0.6V base-emitter offset is cancelled out and thus temperature changes resulting in varying base-emitter voltages will not cause output drift.

That is assuming that Q1 and Q3 are kept at the same temperature but their dissipation will be low and they can be mounted in close proximity or even thermally bonded, so that is not difficult to arrange.

This also has the advantage that the reference voltage can be varied using adjustment pot VR1 right down to 0V; and so the output voltage can go down to 0V as well.

However, it then becomes necessary to provide a negative voltage at the emitters of Q1 and Q3 so that they can remain in conduction with a zero base voltage.

These emitters are connected to the second constant-current source, I2, and current flows through it to a negative supply which is regulated by zener diode ZD1.

The negative supply is generated by a separate rectifier/filter from the transformer (D3 and C2); the bias current for zener diode ZD1 is supplied via resistor R1.

Using a current source (I2) to define the current from the emitters of the long-tailed pair transistors also ensures maximum performance of the differential amplifier, giving a high common-mode rejection ratio.

This means that gain (and thus, regulation) is the same for all base-to-base voltage differences regardless of the actual voltage with respect to ground, ie, from maximum output to zero.

For more details on how this type of regulator works, refer to the book "Understanding DC Power Supplies and Oscillators" by Barry Davis.

This basic design shown in Fig.2 was used in the first-generation µA/LM723 regulator IC. Although it was the device of choice for many pieces of solid state equipment, it was limited by being a low-voltage design.

Valves in the output stage

Discrete semiconductor devices had limited voltage ratings at the time the BWD 216A was designed and it would have been impractical to design a 400V regulated supply using readily available semiconductors.

As a result, the 216A uses a combination of valve and solid-state components, ie, it is a hybrid power supply. The valves are used as the pass elements: four 6CA7/EL34s in the 0-400V section and a single 6CW5 in the 0-250V section.

The control circuits use a combination of bipolar junction transistors (BJTs), junction field-effect transistors (JFETs) and silicon integrated circuits in the form of two CA3054 general-purpose dual differential amplifiers (one for the 0-400V section and another for the 0-250V).

Using thermionic valves as the output devices has another advantage which is that they can handle much higher dissipation than a semiconductor device without heatsinking, since they are made from glass and steel, rather than silicon which has a much lower failure temperature. And they are physically large and therefore more effective at radiating all that heat.

Using a valve pass element usually demands that the control circuit can drive the valve's grid voltage from near zero (for maximum output) to cutoff (for minimum output). The triode-connected 6CA7s require up to 90V of negative grid bias for full cut-off.

BWD took the innovative approach of referencing the control circuit positive supply to the regulated output, thus effectively "floating" it with the output voltage. This allows the control circuitry to work at low internal voltages.

The 216A takes a different approach to biasing as well. The control circuit applies a fixed 11V bias to the 6CA7 grids, then uses paralleled transistors to sink current from the valve cathodes. By controlling the equivalent resistance of the cathode-circuit transistors, it controls the output voltage.

The transistors need a maximum voltage rating of some 100V (to provide the -90V bias described above) but it's still the 6CA7 valves that handle the majority of the 600V DC unregulated supply, dropping this to the required output voltage.

0V output at the full rated 200mA load current (the worst case for dissipation) results in around 120W loss in the pass circuitry. As four valves are connected in parallel, each will dissipate up to 30W, just within the 6CA7's specified dissipation limit of 33W.

Circuit description

A complete service manual for the BWD 216A is available from Kevin Chant's excellent website, at siliconchip.com.au/link/aalx

This includes diagrams showing the circuit for each output separately, as well as a hand-drawn (and barely legible) complete circuit at the end.

Be aware that the circuit for the 0-400V output (BWD drawing 1204) in this manual, reproduced in Fig.6, has an error; it omits the biasing for the internal current generator at pin 3 of IC1, which connects to resistors R30 and R32. The correct connections are shown in Fig.5. Drawings 1205 and 910 in the service manual are correct.

The following is a somewhat simplified description of the circuit.

Mains transformer T1 has a split primary winding, allowing for 110VAC (85-137V) or 230/240VAC (185-260V) operation.

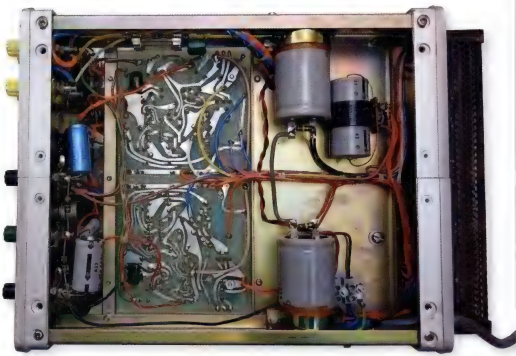
It also has eight secondaries: a 440VAC winding for the 0-400V DC regulator; a 290VAC winding for the 0-250V DC regulator; two separate 6.3VAC heater windings for the 0-400V regulator valves and the 250V regulator valve; two 30VAC windings for the solid-state sections of the two regulators; and two 6.3VAC windings brought out to the front panel to power external loads.

Let's start by looking at the two internal low-voltage power supplies for the solid state control circuitry. They are virtually identical, with one used for the 400V output and one for the 250V output. This portion of the circuit is shown in Fig.3.

The 30VAC from the transformer secondary is half-wave rectified by diode D5 and filtered by 68µF capacitor C6. The resulting pulsating DC is then regulated by a conventional and delightfully simple low-voltage regulator using transistors Q10-Q12, with zener diode D11 acting as the local reference voltage.

Q11, the NPN pass transistor, is controlled by NPN transistor Q12. 6.2V zener diode D11 is connected to Q12's emitter while a sample of the output voltage is applied to its base, after having been divided by a factor of 2.47 due to resistors R17/R18. JFET Q10 (selected for a suitable IDSS [drain-source current]) forms the constant-current collector load for Q12.

This supply's overall output is around 17V DC but it is referenced to the 0-400V output which is connected to the cathode of zener diode D11 (labelled "0V"). So the output at the emitter of Q11 sits at around +11V relative to the output voltage. This is used as the positive supply for the two differential amplifiers within IC1 and is also the source of the fixed +11V grid bias for valves V1-V4.



The internal underside view of the BWD 216A primarily shows the large capacitors and a few resistors.

The -6.2V which appears at the anode of D11 (relative to the output voltage) is used as the negative supply for the long-tailed pair connections of these two differential amplifiers (IC1A/B), and in the current-sensing circuitry.

The +11V supply is also fed to 2N3819 JFETs Q13 and Q14 as shown in Fig.4, which combine to form a 4mA constant-current source, which is trimmed using trimpot RV2.

This current is fed to 100kΩ wirewound potentiometer RV1 and so a voltage of between 0-400V appears at the top end of RV1, depending on its rotation.

The two FETs are wired in parallel to provide this reference current and each has source biasing, which gives a more stable current.

That's important since any instability in this reference current will be amplified and will cause variations in the output voltage.

Since RV1 is wired as a rheostat, it dissipates a maximum of 1.6W when the output is set to 400V. A wirewound pot can easily cope with this sort of dissipation on a continuous basis.

The two differential amplifiers

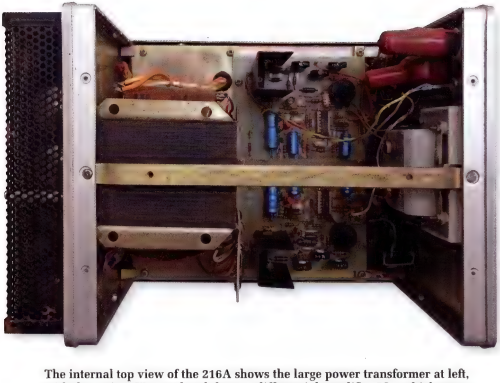
Both differential amplifiers (IC1A & IC1B) are contained within a single CA3054 IC.

This IC includes two balanced transistor pairs, along with transistors which operate as constant-current sinks for the common emitter connections. Each amplifier has an operating frequency range extending to 120MHz and gives a voltage gains of up to 40 times.

The 0-400V reference from RV1 is fed to pin 13 of IC1B, while the supply's output voltage is applied to pin 2, in both cases via 2.2kΩ resistors. This provides the negative feedback to adjust the cathode current of V1-V4, via transistors Q7-Q9, controlling the output voltage as described above.

Keep in mind that all of this circuitry is operating anywhere from 0-400V DC above ground, depending on the output voltage. This is the clever part of the design; the control circuitry is bootstrapped against the 0-400V supply, allowing it to operate at low voltages while controlling a high-voltage output.

To make the following description easier to understand, I have re-drawn part of the 0-400V regulator circuit in



The internal top view of the 216A shows the large power transformer at left, with the main PCB populated the two differential amplifier ICs, which were manufactured by AWA, along with other discrete components.

Fig.5: a simplified circuit of the 0-400V regulator portion of the BWD 216A. Some components have been left out of this circuit for clarity, including the 470pF capacitor and 6.8kΩ resistor wired in series between pins 1 & 2 of IC1B.

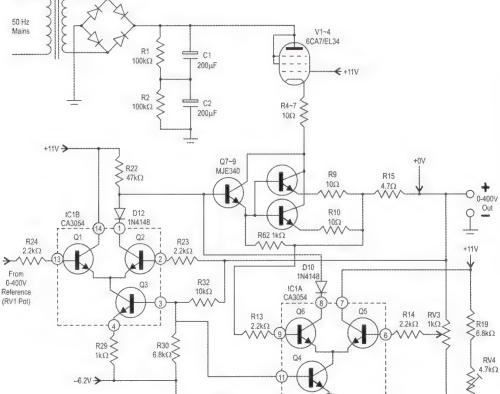


Fig.5, with the internal transistors in the CA3054 ICs shown, so you can see exactly how the circuit works. Note that I have simplified this somewhat, omitting some components which are not critical to understanding how it works.

While differential amplifier IC1B is used to control the output voltage as described above, IC1A provides the adjustable current limit. Since the maximum current setting is equal to the supply's maximum current rating, this also protects the supply against overload.

A compensation network comprising a 470pF capacitor and a 6.8kΩ resistor wired in series is connected between output pin 1 and inverting input pin 2 of IC1B, to stabilise the feedback loop and prevent oscillation (not shown in Fig.5).

The error amplifier's output current at pin 1 passes through diode D12, to the base of NPN transistor Q9, which controls the output stage. 47kΩ resistor R22 provides the current to drive Q7-Q9 and the current flowing through D12 and into pin 1 of IC1B is subtracted from the current flowing into the base of Q9.

This arrangement gives high current gain, and (importantly for any amplifier circuit) presents a high input impedance, giving excellent regulation accuracy.

IC1A works similarly to IC1B but instead of amplifying the difference between the output voltage and the desired voltage, its pin 9 inverting input connects to one end of R15, a 4.7Ω 0.5W wire-wound resistor which is used as a shunt, to measure the output current. As the current increases, so does the voltage across this resistor.

Its non-inverting input connects to the wiper of potentiometer RV3 which is connected to the opposite end of R15 and to the +11V supply rail via some padding resistor, including trimmer RV4.

Thus, RV3 allows the user to control how much current flows through R15 before output pin 8 of IC1A goes low, forwarding-biasing diode D10 and reducing the output voltage. This will then (normally) reduce the output current and the circuit will stabilise at a particular current level, as set using RV3.

With RV3 at the top of its travel, IC1A's input pin 6 receives the full

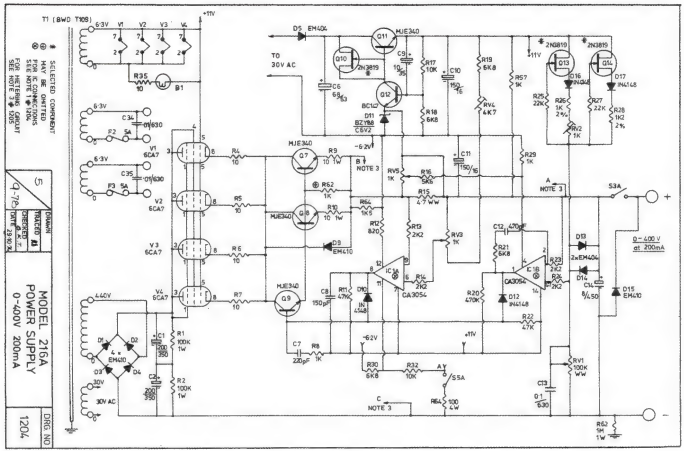


Fig.6 (above): the 0-400V 200mA regulator section of the BWD 216A power supply, reproduced from the service manual.

Fig.7 (below): the separate 0-250V 50mA regulator section of the power supply.

voltage drop across R15 while at the other end of RV3's travel, this input receives a smaller proportion of R15's voltage drop.

An output current of 20mA will create a drop across R15 of some 100mV. With RV3 set to the top end of its travel (minimum current limit on the front panel), this will put IC1A's internal transistor Q6 into conduction, drawing current through D10 and R22, overcoming Q2's voltage control function and reducing the forward bias on transistors Q7-Q9.

As IC1A becomes active, the entire supply can no longer give a constant output voltage, but becomes a constant-current supply instead. At the other end of RV3's travel, the output will deliver its full rated 200mA, assuming trimpot RV4 is correctly adjusted to give the correct voltage at pin 6 of IC1A.

So diodes D10 and D12 allow IC1A and IC1B to independently lower the output voltage when either the voltage or current is above the set-point, without having to "fight" each other. In other words, they form a "wired-or" type network.

Adjustable transient response

A change in the output voltage (when operating in constant-voltage mode) or load current (when operating in constant-current mode) will put the circuit out of balance and its overall negative feedback will cause it to rebalance and return the output to the desired value.

How quickly this happens is a measure of the circuit's transient response. The 0-400V section includes an adjustable positive feedback network (see manufacturer's notes) that allows trimming of the output's dynamic response (via trimpot RV5, not shown on Fig.5) to be optimal.

Generally, you want the output to "undershoot" rather than "overshoot" but it should undershoot by as little as possible to give a fast transient response.

High-voltage source and pass circuitry

The output of the 440VAC secondary from the transformer is fed to a bridge rectifier formed by diodes D1-D4, charging the 200µF 350V filter capacitors C1 and C2 up to around 600V DC. Note that since these capacitors are in series, they effectively form a 100µF 700V capacitor.

It is parallelled by 100kΩ bleed resistors R1/R2 which help to compensate for any difference in leakage currents which may occur in C1 and C2. Without R1/R2, this could cause the capacitors to charge unevenly and one could be charged above its 350V rating.

The resulting 600V DC is applied to the anodes of the four parallelled triode-connected 6CA7/ EL34s (V1-V4). The 6AS7/6080 twin triode often used in power supplies is limited to 250V DC but the 800V DC rating of the 6CA7 valves makes them an ideal choice here.

Cathode resistors R4-R7 compensate for differences in the valve characteristics, so they share the load more or less evenly. The cathode control circuit contains paralleled transistors Q7/Q8. These are in turn controlled by emitter-follower transistor Q9, which forms a Darlington Pair with Q7/Q8.

Although the transistors are in series with the valves, their primary purpose is to control valve cathode current rather than act as primary pass elements.

Essentially, the valves amplify the voltage across the transistors, "shielding" them from the high voltage difference which would otherwise cause breakdown and destruction.

Working on this unit

If you've just powered down one of these supplies and want to work on it, you will have to be careful with the charge on the two 200µF 350V filter capacitors for the 0-400V regulator and the 32µF 500V filter capacitor for the 0-250V regulator.

These can retain a substantial charge for several minutes after switch-off and could give a lethal shock if not fully discharged before working on the circuit.

Discharging high-voltage capacitors with a screwdriver looks pretty impressive. Hopefully, if you do this, you'll escape injury from flying vaporised metal. But I recommend against it. Such actions cause massive current spikes and it's quite possible that this will destroy solid-state components.

If you can't be bothered to wait a few minutes to let the parallel resistors discharge these capacitors, try connecting a 4.7kΩ 5W resistor across them.

Chassis layout and clean-up

The major components are mounted on the chassis, with the five valves (four 6CA7/EL34s and one 6CW5/EL86) inside a protective cover at the rear. Smaller components are mounted on a printed circuit board, with the 0-400V DC section on the left and the 0-250V DC section on the right.

I acquired three of these supplies at

The valves have a warmup time of about 15 seconds and this has the beneficial side effect of preventing switch-on surges if a load is connected.

BWD a short history

1960~1980 was a Golden Age for Australian manufacturing and electronics was no exception. Back then, we designed and made test equipment that was the equal of even world-leading manufacturers such as Tektronix and Hewlett-Packard.

Our best-known local hero was BWD who supplied bench, laboratory and storage oscilloscopes, a large-screen (17-inch) oscilloscope, function/sweep/signal generators and power supplies among other devices.

Founded in 1955 by John Beesley, Peter Wingate and Bob Dewey, they first occupied premises in Auburn, Melbourne near the Geebung hotel. Friday afternoons down the pub would have given a foretaste of California's Silicon Valley a decade or so later. The company prospered, moving to 333 Burke Road, Glen Iris and ultimately to Mulgrave.

BWD was eventually purchased by McVan Instruments, which continues business in Mulgrave.

John Beesley remained involved with BWD until 1989 when he went to work for Cochlear, inventors of the Bionic Ear.

The 216's Instrument Handbook lists sixty-four parts suppliers, all either entirely local or local distributors of overseas products. Oh, for the glory days of Aussie manufacturing!

BWD gear satisfied educational, service department, research and scientific consumers. Sound design, reliability and ease of use made equipment such as the 216 popular and sought after.

While some designs were intricate, BWD's local presence made service data easy to acquire and repairs could be made quickly and easily.

The 216 was apparently a very successful design. The set described here has a serial number of 35,109 and the final version of the service manual (Issue 5) applies to units with serial numbers over 40,000, so at least that many were made.

ELECTRONIC
TEST INSTRUMENTS
Shortform catalogue №7
BWD Electronics Pty. Ltd.

a giveaway at a local TAFE last century. They were ex-lab equipment and two were in good cosmetic condition but the third was missing some bits. It had obviously been Christmas-tree'd for parts.

I picked the best one and gave it a good clean-up. I then tested it. I couldn't get an output of more than about 150V DC from the 0-400V supply. This suggested that one of the reference JFETs (Q13 or Q14) was dead, preventing the full 400V from appearing across voltage adjustment pot RV1. I replaced both, restoring the 400V output to its full adjustment range.

The 250V output tested OK. All five valves checked out 100%, so I used one of BWD's test sheets (still in the handbook) to check the other functions of the supply. Some calibrations were a bit off but were easily brought back to spec.

The only special components are the two CA3054 ICs (available online) and the meter, so any other faults can be fixed pretty easily.

Note that there is a potential problem with this design. If the 100kΩ output control pot (RV1) goes open circuit, the current source will drag the reference voltage up towards 600V. This will greatly exceed C14's voltage rating and it could explode. If you are using a BWD 216 power supply and the 400V output voltage suddenly skyrockets, turn it off at once.

Replacement wirewound pots are available online from overseas. Be sure to get a type with a power rating of at least 2W. I've added 400V zener chains across RV1 in my 216s so that if the pot does go open, I'll just get an uncontrollable 400V output as a warning, and hopefully no explosions. A crowbar circuit would be an even more elegant protection mechanism.

Conclusion

This is a great piece of test gear. Like many of BWD's offerings, it's an example of local Aussie design that compares favourably to the best imports in its price range.

Applying a full load of 200mA to the 400V supply dropped the output by only 7mV, a reduction of 0.0017%. The valve pass elements do mean there's an initial warmup delay of some 15 seconds for full operation but that's hardly unreasonable.

The two independent supplies provide lots of options. Some of my favourite vintage aircraft radio and television gear requires a +400V HT supply but also demands a -150V bias supply and the 216A can easily supply both.

If you see one of these in fair condition, I suggest you snap it up. The most common fault is an open Output Control pot and a subsequently exploded electrolytic filter capacitor across the output terminals (C14).

These faults are easily fixed, and you'll have a high-performing, reliable power supply that'll power all things "valve" from hearing aids up to medium-sized valve TVs and most military radios.

Watch out, though, for a meter with a detached pointer – the aluminium used appears to oxidise with age and fall off. SC

SILICON CHIP ONLINESHOP
siliconchip.com.au/shop

Looking for a specialised component to build that latest and greatest SILICON CHIP project? Maybe it's the PCB you're after? Or a pre-programmed micro? Or some other hard-to-get "bit"? The chances are they are available direct from the SILICON CHIP Online Shop.

- PCBs are normally IN STOCK and ready for despatch when that month's magazine goes on sale (you don't have to wait for them to be made!).
- Even if stock *runs out* (eg, for high demand), in most cases there will be no longer than a two-week wait.
- One low p&p charge: $10 per order, irregardless of how many items you order! (AUS only; overseas clients – check the website for a postage quote).
- Our PCBs are beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.
- Best of all, subscribers receive a **10%** discount on purchases! (Excluding subscription renewals and postage costs)

HERE'S HOW TO ORDER:

VISA MasterCard PayPal

All prices are in AUSTRALIAN DOLLARS ($AUD)

- **INTERNET** (24 hours, 7 days): Log on to our secure website – siliconchip.com.au, click on "SHOP" and follow the links
- **EMAIL** (24 hours, 7 days): email silicon@siliconchip.com.au – Clearly tell us what you want and include your contact and credit card details
- **MAIL** (24 hours, 7 days): PO Box 139, Collaroy NSW 2097. Clearly tell us what you want and include your contact and credit card details
- **PHONE** (9am-5pm AET, Mon-Fri): Call (02) 9939 3295 (INT +612 9939 3295) – have your order ready, including contact and payment details!

YES! You can also order or renew your SILICON CHIP subscription via any of these methods as well!

PRE-PROGRAMMED MICROS

Micros cost from $10.00 to $20.00 each + $10 p&p per order#

$10 MICROS

ATtiny816	ATtiny816 Development/Breakout Board (Jan19)
PIC12F617-I/P	Temperature Switch MK2 (June18), Recurring Event Reminder (Jul18) Door Alarm (Aug18), Steam Whistle (Sept18) White Noise / Insomnia Killer (Sept18 / Nov18), **Remote Control Dimmer (Feb19)**
PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10) Ultrasonic Anti-hauling (Sep10), Cricket/Frog Call (Jan12), Do Not Disturb (May13) IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13) PC Birdies *2 chips – $15 pair^* (Aug13), Driveway Monitor Receiver (July15) Hotel Safe Alarm (Jan16), 50A Battery Charger Controller (Nov16) Kelvin the Cricket (Oct17), Triac-based Mains Motor Speed Controller (Mar18) Heater Controller (Apr18), Useless Box IC3 (Dec18)
PIC12F675-E/P	Courtesy LED Light Delay for Cars (Oct14), Fan Speed Controller (Jan18)
PIC16F1455-I/P	Microbridge (May17), USB Flexitimer (June18), Digital Interface Module (Nov18)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13) Auto Headlight Controller (Oct13), 10A 230V Motor Speed Controller (Feb14) Automotive Sensor Modifier (Dec15)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11) Quizzical (Oct11), Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13) Nicad/NiMH Battery Charger (Mar14), Remote Mains Timer (Nov14) Driveway Monitor Transmitter (July15), Fingerprint Scanner (Nov15) MPPT Lighting Charge Controller (Feb16), 50/60Hz Turntable Driver (May16) Cyclic Pump Timer (Sept16), 60V 40A DC Motor Speed Controller (Jan17) Pool Lap Counter (Mar17), Rapidbrake (Jul17), Deluxe Frequency Switch (May18) Useless Box IC1 (Dec18)
PIC16LF88-I/P	Garbage Reminder (Jan13), Bellbird (Dec13), GPS Analog Clock Driver (Feb17)

$15 MICROS

PIC16F1459-I/SO	Four-Channel DC Fan & Pump Controller (Dec18)
PIC16F84A-20I/P	Programmable Ignition Timing Module (Jun99), Fuel Mixture Display (Sept00) Oscar Naughts And Crosses (Oct07), UV Lightbox Timer (Nov07)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), 16-bit Digital Pot (Jul10), Semtest (Feb-May12)
PIC16F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F4550-I/P	Multi-Purpose Car Scrolling Display (Dec08), GPS Car Computer (Jan10)
PIC32MM0256GPM028-I/SS	Super Digital Sound Effects (Aug18)
PIC32MX170F256B-50I/SP	Micromite MK2 (Jan15) + **47µF** Low Frequency Distortion Analyser (Apr15) Micromite LCD BackPack (either version) (Feb16), GPS Boat Computer (Apr16) Micromite Super Clock (Jul16), Touchscreen Voltage/Current Ref (Oct-Dec16) Micromite LCD BackPack V2 (May17), Deluxe eFuse (Aug17) Micromite DDS for IF Alignment (Sept17), Tariff Clock (Jul18) GPS-Synched Frequency Reference (Nov18)
PIC32MX270F256B-50I/SP	ASCII Video Terminal (Jul14), **USB Mouse & Keyboard Adaptor (Feb19)**
PIC32MX795F512H-80I/PT	Maximite (May11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12) Touchscreen Audio Recorder (Jun/Jul 14)
dsPIC33FJ64MC802-E/SP	Induction Motor Speed Controller (revised) (Aug13)

$20 MICROS

PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14) Digital Effects Unit (Oct14)
PIC32MX470F512H-120/PT	Micromite PLUS Explore 64 (Aug 16), Micromite Plus LCD BackPack (Nov16)
PIC32MX470F512L-120/PT	Micromite PLUS Explore 100 (Sep-Oct16)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Cont. (Oct-Dec10) SpotSync (May11), Digital Audio Delay (Dec11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)

When ordering, be sure to select BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, HARD-TO-GET BITS, ETC

P&P – $10 Per order#

TOUCH & IR REMOTE CONTROL DIMMER *(FEB 19)*
- N-channel Mosfets Q1 & Q2 (SIHB15N60E) and two 4.7MΩ 3.5kV resistors – **$20.00**
- IRD1 (TSOP4136) and fresnel lens (IML0688) – **$10.00**

MOTION SENSING SWITCH (SMD VERSION) *(FEB 19)*
- Short form kit (includes PCB and all parts, except for the extension cable) – **$10.00**
- SW-18010P vibration sensor (S1) – **$1.00**

DIGITAL INTERFACE MODULE KIT (CAT SC4750) *(NOV 18)*
Includes PCB, programmed micro and all other required onboard components – **$15.00**

TINNITUS/INSOMNIA KILLER HARD-TO-GET PARTS (CAT SC4792) *(NOV 18)*
One LF500V regulator (TO-220) and LM4865MO audio amplifier IC (SOIC-8) – **$10.00**

GPS-SYNCHED FREQUENCY REFERENCE SMD PARTS (CAT SC4762) *(NOV 18)*
Includes PCB and all SMD parts required – **$80.00**

STEAM WHISTLE / DIESEL HORN (CAT SC4696) *(SEPT 18)*
Set of two programmed PIC12F617-I/P micros – **$15.00**

SUPER DIGITAL SOUND EFFECTS KIT (CAT SC4658) *(AUG 18)*
PCB and all onboard parts (including optional ones) but no SD card, cell or battery holder – **$40.00**

RECURRING EVENT REMINDER PCB+PIC BUNDLE (CAT SC4641) *(JUL 18)*
PCB and programmed micro for a discount price – **$15.00**

USB PORT PROTECTOR COMPLETE KIT (CAT SC4574) *(MAY 18)*
All parts including the PCB and a pair of clear heatshrink tubing – **$15.00**

AM RADIO TRANSMITTER (CAT SC4533) *(MAR 18)*
MC1496P double-balanced mixer IC (DIP-14) – **$2.50**

VINTAGE TV A/V MODULATOR *(MAR 18)*
MC1374P A/V modulator IC (DIP-14) (Cat SC4543) – **$5.00**
SBK-71K cold former pack (**two required**) (Cat SC2746) – **$5.00 ea.**

PARTS FOR THE 6GHz+ TOUCHSCREEN FREQUENCY COUNTER *(OCT 17)*
Explore 100 kit (Cat SC3834, no LCD included) – **$69.90**
one ERA-2SM+ & one ADCH-80A+ (Cat SC1167; **two required**) – **$15.00/pk.**

MICROBRIDGE COMPLETE KIT (CAT SC4264) *(MAY 17)*
PCB plus all on-board parts including programmed microcontroller (SMD ceramics for 100pF) – **$20.00**

MICROMITE LCD BACKPACK V2 – COMPLETE KIT (CAT SC4237) *(MAY 17)*
includes PCB, programmed micro, touchscreen LCD, laser-cut UB3 lid, mounting hardware, SMD Mosfets for PWM backlight control and all other on-board parts – **$70.00**

SC200 AMPLIFIER MODULE (CAT SC4140) *(JAN 17)*
Hard-to-get parts: Q9-Q16, EZ-24, 150pF/250V capacitor and five SMD resistors – **$35.00**

VARIOUS MODULES & PARTS
- MCP1700 3.3V LDO regulator (suitable for USB Mouse & Keyboard Adaptor, FEB19) – **$1.50**
- LM4865MX amplifier IC & LF500V regulator (Tinnitus/Insomnia Killer, NOV18) – **$10.00**
- 2.8-inch touchscreen LCD module with SD card socket (Tide Clock, JUL18) – **$22.50**
- ESP-01 WiFi Module (El Cheapo Modules, Part 15, APR18) – **$5.00**
- WiFi Antennas with U.FL/IPX connectors (Water Tank Level Meter with WiFi, FEB18): 5dBi – **$12.50** – 2dBi (omnidirectional) – **$10.00**
- MRF24J01+PA+LNA transceiver SMA connector and antenna (El Cheapo 12, JAN18) – **$5.00**
- WeMos D1 Arduino-compatible boards with WiFi (SEPT17, FEB18): ThingSpeak data logger – **$10.00** – WiFi Tank Level Meter (ext. antenna socket) – **$15.00**
- Geetech Arduino MP3 shield (Arduino Music Player/Recorder, V51053, JUL17) – **$20.00**
- 1nF 1% MKP (5mm lead spacing) or ceramic capacitor (Wide-Range LC Meter, JUN18) – **$2.50**
- MAX7219 LED controller boards (El Cheapo Modules, Part 7, JUN17): 8x8 red SMD/DIP matrix display – **$5.00** – red 8-digit 7-segment display – **$7.50**
- AD9833 DDS module (with gain control) (for Micromite DDS, APR17) – **$25.00**
- AD9833 DDS module (no gain control) (El Cheapo Modules, Part 6, APR17) – **$15.00**
- CP2102 USB UART bridge – **$5.00**
- microSD card adaptor (El Cheapo Modules, Part 3, JAN17) – **$2.50**
- DS3231 real-time clock with mounting spacers and screws (El Cheapo, Part 1, OCT16) – **$5.00**

THESE ARE ONLY THE MOST RECENT MICROS AND SPECIALISED COMPONENTS. FOR THE FULL LIST, SEE siliconchip.com.au/shop

*All items subject to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and include GST where applicable. **# P&P prices are within Australia. O'seas? Please email for a quote***

02/19

PRINTED CIRCUIT BOARDS

NOTE: The listings below are for the PCB ONLY. If you want a kit, check our store or contact the kit suppliers advertising in this issue. For unusual projects where kits are not available, some have specialised components available – see the list opposite.

NOTE: Not all PCBs are shown here due to space limits but the SILICON CHIP Online Shop has boards going back to 2001 and beyond. For a complete list of available PCBs etc, go to siliconchip.com.au/shop/8 Prices are PCBs only, NOT COMPLETE KITS!

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMITE ASCII VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141a/b	$15.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
44-PIN MICROMITE	AUG 2014	24114141	$5.00
OPTO-THEREMIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THEREMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10.00/set
MINI-D AMPLIFIER	SEP 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (DI) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR DONGLE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30.00/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015	SC2892	$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
APPLIANCE INSULATION TESTER FRONT PANEL	APR 2015	04103152	$10.00
LOW-FREQUENCY DISTORTION ANALYSER	APR 2015	04104151	$5.00
APPLIANCE EARTH LEAKAGE TESTER PCBs (2)	MAY 2015	04203151/2	$15.00
APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$15.00
BALANCED INPUT ATTENUATOR MAIN PCB	MAY 2015	04105151	$15.00
BALANCED INPUT ATTENUATOR FRONT & REAR PANELS	MAY 2015	04105152/3	$20.00
4-OUTPUT UNIVERSAL ADJUSTABLE REGULATOR	MAY 2015	18105151	$5.00
SIGNAL INJECTOR & TRACER	JUNE 2015	04106151	$7.50
PASSIVE RF PROBE	JUNE 2015	04106152	$2.50
SIGNAL INJECTOR & TRACER SHIELD	JUNE 2015	04106153	$5.00
BAD VIBES INFRASOUND SNOOPER	JUNE 2015	04104151	$5.00
CHAMPION × PRE-CHAMPION	JUNE 2015	01109121/2	$7.50
DRIVEWAY MONITOR TRANSMITTER PCB	JULY 2015	15105151	$10.00
DRIVEWAY MONITOR RECEIVER PCB	JULY 2015	15105152	$5.00
MINI USB SWITCHMODE REGULATOR	JULY 2015	18107151	$2.50
VOLTAGE/RESISTANCE/CURRENT REFERENCE	AUG 2015	04108151	$2.50
LED PARTY STROBE MK2	AUG 2015	16101141	$7.50
ULTRA-LD MK4 200W AMPLIFIER MODULE	SEP 2015	01107151	$15.00
9-CHANNEL REMOTE CONTROL RECEIVER	SEP 2015	15108151	$15.00
MINI USB SWITCHMODE REGULATOR MK2	SEP 2015	18107152	$2.50
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	OCT 2015	01205141	$20.00
ULTRA LD AMPLIFIER POWER SUPPLY	OCT 2015	01109111	$15.00
ARDUINO USB ELECTROCARDIOGRAPH	OCT 2015	07108151	$7.50
FINGERPRINT SCANNER – SET OF TWO PCBS	NOV 2015	03109151/2	$15.00
LOUDSPEAKER PROTECTOR	NOV 2015	01110151	$10.00
LED CLOCK	DEC 2015	19110151	$15.00
SPEECH TIMER	DEC 2015	19111151	$15.00
TURNTABLE STROBE	DEC 2015	04101161	$5.00
CALIBRATED TURNTABLE STROBOSCOPE ETCHED DISC	DEC 2015	04101162	$10.00
VALVE STEREO PREAMPLIFIER – PCB	JAN 2016	01101161	$15.00
VALVE STEREO PREAMPLIFIER – CASE PARTS	JAN 2016	01101162	$20.00
QUICKBRAKE BRAKE LIGHT SPEEDUP	JAN 2016	05102161	$15.00
SOLAR MPPT CHARGER & LIGHTING CONTROLLER	FEB/MAR 2016	16101161	$15.00
MICROMITE LCD BACKPACK, 2.4-INCH VERSION	FEB/MAR 2016	07102121	$7.50
MICROMITE LCD BACKPACK, 2.8-INCH VERSION	FEB/MAR 2016	07102122	$7.50
BATTERY CELL BALANCER	MAR 2016	11111151	$6.00
DELTA THROTTLE TIMER	MAR 2016	05102161	$15.00
MICROWAVE LEAKAGE DETECTOR	APR 2016	04103161	$5.00
FRIDGE/FREEZER ALARM	APR 2016	03104161	$5.00
ARDUINO MULTIFUNCTION MEASUREMENT	APR 2016	04116011/2	$15.00
PRECISION 50/60Hz TURNTABLE DRIVER	MAY 2016	04104161	$15.00
RASPBERRY PI TEMP SENSOR EXPANSION	MAY 2016	24104161	$5.00
1000B STEREO AUDIO LEVEL/VU METER	JUN 2016	01104161	$15.00
HOTEL SAFE ALARM	JUN 2016	03106161	$5.00
UNIVERSAL TEMPERATURE ALARM	JULY 2016	03105161	$5.00
BROWNOUT PROTECTOR MK2	JULY 2016	10107161	$10.00
8-DIGIT FREQUENCY METER	AUG 2016	04105161	$10.00
APPLIANCE ENERGY METER	AUG 2016	04116061	$15.00
MICROMITE PLUS EXPLORE 64	AUG 2016	07108161	$5.00
CYCLIC PUMP/MAINS TIMER	SEPT 2016	10108161/2	$10.00/pair
MICROMITE PLUS EXPLORE 100 (4 layer)	SEPT 2016	07109161	$20.00
AUTOMOTIVE FAULT DETECTOR	SEPT 2016	05109161	$10.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
MOSQUITO LURE	OCT 2016	25110161	$5.00
MICROPOWER LED FLASHER	OCT 2016	16109161	$5.00
MINI MICROPOWER LED FLASHER	OCT 2016	16109162	$2.50
50A BATTERY CHARGER CONTROLLER	NOV 2016	11111161	$10.00
PASSIVE LINE TO PHONO INPUT CONVERTER	NOV 2016	01111161	$5.00
MICROMITE PLUS LCD BACKPACK	NOV 2016	07110161	$7.50
AUTOMOTIVE SENSOR MODIFIER	DEC 2016	05111161	$10.00
TOUCHSCREEN VOLTAGE/CURRENT REFERENCE	DEC 2016	04110161	$12.50
SC200 AMPLIFIER MODULE	JAN 2017	01108161	$10.00
60V 40A DC MOTOR SPEED CON. CONTROL BOARD	JAN 2017	11112161	$10.00
60V 40A DC MOTOR SPEED CON. MOSFET BOARD	JAN 2017	11112162	$12.50
GPS SYNCHRONISED ANALOG CLOCK	FEB 2017	04202171	$10.00
ULTRA LOW VOLTAGE LED FLASHER	FEB 2017	16110161	$2.50
POOL LAP COUNTER	MAR 2017	19102171	$15.00
STATIONMASTER TRAIN CONTROLLER	MAR 2017	09103171/2	$15.00/set
EFUSE	APR 2017	04102171	$7.50
SPRING REVERB	APR 2017	01104171	$12.50
6GHz+ 1000:1 PRESCALER	MAY 2017	04112162	$7.50
MICROBRIDGE	MAY 2017	24104171	$2.50
MICROMITE LCD BACKPACK V2	MAY 2017	07104171	$7.50
10-OCTAVE STEREO GRAPHIC EQUALISER PCB	JUN 2017	01105171	$12.50
10-OCTAVE STEREO GRAPHIC EQUALISER FRONT PANEL	JUN 2017	01105172	$15.00
10-OCTAVE STEREO GRAPHIC EQUALISER CASE PIECES	JUN 2017	SC4281	$15.00
RAPIDBRAKE	JUL 2017	05105171	$10.00
DELUXE EFUSE	AUG 2017	18106171	$5.00
DELUXE EFUSE UB1 LID	AUG 2017	SC4316	$5.00
MAINS SUPPLY FOR BATTERY VALVES (INC. PANELS)	AUG 2017	18108171-4	$25.00
3-WAY ADJUSTABLE ACTIVE CROSSOVER	SEPT 2017	01108171	$20.00
3-WAY ADJUSTABLE ACTIVE CROSSOVER PANELS	SEPT 2017	01108172/3	$20.00/pair
3-WAY ADJUSTABLE ACTIVE CROSSOVER CASE PIECES	SEPT 2017	SC4403	$10.00
6GHz+ TOUCHSCREEN FREQUENCY COUNTER	OCT 2017	04110171	$10.00
KELVIN THE CRICKET	OCT 2017	08109171	$10.00
6GHz+ FREQUENCY COUNTER CASE PIECES (SET)	DEC 2017	SC4444	$15.00
SUPER-7 SUPERHET AM RADIO PCB	DEC 2017	08111171	$25.00
SUPER-7 SUPERHET AM RADIO CASE PIECES	DEC 2017	SC4464	$25.00
THEREMIN	JAN 2018	23112171	$12.50
PROPORTIONAL FAN SPEED CONTROLLER	JAN 2018	05111171	$2.50
WATER TANK LEVEL METER (INCLUDING HEADERS)	FEB 2018	21110171	$7.50
10-LED BARAGRAPH	FEB 2018	04101181	$7.50
10-LED BARAGRAPH SIGNAL PROCESSING	FEB 2018	04101182	$5.00
TRIAC-BASED MAINS MOTOR SPEED CONTROLLER	MAR 2018	10102181	$10.00
VINTAGE TV A/V MODULATOR	MAR 2018	02104181	$7.50
AM RADIO TRANSMITTER	MAR 2018	08101181	$7.50
HEATER CONTROLLER	APR 2018	10104181	$10.00
DELUXE FREQUENCY SWITCH	MAY 2018	05104181	$7.50
USB PORT PROTECTOR	MAY 2018	07105181	$2.50
2 x 12V BATTERY BALANCER	MAY 2018	14106181	$2.50
USB FLEXTIMER	JUNE 2018	19106181	$7.50
WIDE-RANGE LC METER	JUNE 2018	04106181	$5.00
WIDE-RANGE LC METER (INCLUDING HEADERS)	JUNE 2018	SC4618	$7.50
WIDE-RANGE LC METER CLEAR CASE PIECES	JUNE 2018	SC4609	$7.50
TEMPERATURE SWITCH MK2	JUNE 2018	05105181	$7.50
LilyPO4 UPS CONTROL SHIELD	JUNE 2018	11106181	$5.00
RASPBERRY PI TOUCHSCREEN ADAPTOR (TIDE CLOCK)	JULY 2018	24108181	$5.00
RECURRING EVENT REMINDER	JULY 2018	19107181	$5.00
BRAINWAVE MONITOR (EEG)	AUG 2018	25107181	$10.00
SUPER DIGITAL SOUND EFFECTS	AUG 2018	01107181	$2.50
DOOR ALARM	AUG 2018	03107181	$5.00
STEAM WHISTLE / DIESEL HORN	SEPT 2018	09106181	$5.00
DCC PROGRAMMER	OCT 2018	09107181	$5.00
DCC PROGRAMMER (INCLUDING HEADERS)	OCT 2018	09107187	$7.50
OPTO-ISOLATED RELAY (WITH EXTENSION BOARDS)	OCT 2018	10107181/2	$7.50
GPS-SYNCHED FREQUENCY REFERENCE	NOV 2018	04107181	$7.50
NOVEL TIMER	NOV 2018	16107181	$5.00
1 x LED CHRISTMAS TREE	NOV 2018	16107182	$5.00
4 x LED CHRISTMAS TREE	NOV 2018	16107183	$18.00
18 x LED CHRISTMAS TREE			$72.00
31 x LED CHRISTMAS TREE			$120.00
38 x LED CHRISTMAS TREE			$145.00
DIGITAL INTERFACE MODULE	NOV 2018	16107182	$2.50
TINNITUS/INSOMNIA KILLER (JAYCAR VERSION)	NOV 2018	01110181	$5.00
TINNITUS/INSOMNIA KILLER (ALTRONICS VERSION)	NOV 2018	01110182	$5.00
HIGH-SENSITIVITY MAGNETOMETER	DEC 2018	04101011	$12.50
USELESS BOX	DEC 2018	08111181	$7.50
FOUR-CHANNEL DC FAN & PUMP CONTROLLER	DEC 2018	05108181	$5.00
ATtiny816 DEVELOPMENT/BREAKOUT BOARD	JAN 2019	24110181	$5.00
ISOLATED SERIAL LINK	JAN 2019	24107181	$5.00

NEW PCBs

TOUCH & IR REMOTE CONTROL DIMMER MAIN PCB	FEB 2019	10111191	$10.00
REMOTE CONTROL DIMMER MOUNTING PLATE	FEB 2019	10111192	$10.00
REMOTE CONTROL DIMMER EXTENSION PCB	FEB 2019	10111193	$10.00
MOTION SENSING SWITCH (SMD) PCB	FEB 2019	16102191	$5.00
USB MOUSE AND KEYBOARD ADAPTOR PCB	FEB 2019	24311181	$5.00

WE ALSO SELL AN A2 REACTANCE WALLCHART, RADIO, TV & HOBBIES DVD PLUS VARIOUS BOOKs IN THE "Books, DVDs, etc" PAGE AT SILICONCHIP.COM.AU/SHOP/3

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Legality and safety of mains equipment

I have been a reader and subscriber of your magazine for many years. Recently, I disassembled the failed controller of a domestic rainwater pump and discovered something that I would consider dangerous.

The Triac on the back of the controller board is connected directly to the Active conductor of the mains supply and turns the pump on and off. It is mounted on an Earthed metal plate that is in direct contact with the water delivered to the house. Is this legal and is it safe? (M. W., Murray Bridge, SA)

● That construction method is safe and legal. The metal plate is Earthed and the water is only making contact with the Earthed metal plate. The Triac would be an isolated tab type where its metal tab is not connected to any of the Triac pins. This isolates the Triac pin connections from the mains Active.

The construction method is no different to any of the Triac mains controllers that SILICON CHIP have published where the Triac tab is secured to the Earthed metal case. We use an isolated tab Triac in these projects.

In the distant past at *Electronics Australia*, before isolated tab Triacs were available, the non-isolated tab Triacs were attached to the Earthed metal case using an insulating mica washer and insulation bush.

Mains wiring does not radiate much EMI

Is there any way to "clean up" the household mains Earth? As the mains Earth is running parallel to the Active wire in the household power circuit, there must be some kind of induction there, especially for some of the units at a distance from the switch-room Earth. As in the power circuit, there must be an amount of hash-type interference, surely. So how can I eliminate it? (D. S., Penshurst, NSW)

● There is no need to "clean up" your household mains Earth wiring. In reality, there is not a great deal of interference conducted by mains wiring when you have the Active, Neutral and Earth wires closely coupled, as in a 3-core mains cord or 3-core mains cabling in a house.

As you say, there is induction between the Active and Earth (also to Neutral) but it is this very coupling which mostly causes cancellation of the magnetic fields produced by the Active, Neutral and Earth wires. In any case, the voltages in the Earth wiring usually are very small, and any mains hash on the Earth wiring would be very small.

Help to find op amp for Tinnitus Killer

I am building the Insomnia and Tinnitus killer project, published in your November 2018 issue (**siliconchip.com.au/Article/11308**).

The LMC6482AIN dual CMOS op amp is not listed in the Jaycar or Altronics catalogs. Can I use Jaycar Cat ZL3482 instead? (C. T., via email)

● ZL3482 is the Jaycar catalog code for the part that we specified, an LMC6482AIN dual op amp. You can verify this by going to **www.jaycar.com.au** and typing "ZL3482" in the search box. Then scroll to the description at the bottom of the item which appears and you will see that it has the correct part code.

Full-Wave Motor Speed Controller 5V supply

I am confused about the 5V supply to the Full-Wave Universal Motor Speed Controller (March 2018: **siliconchip.com.au/Article/10998**).

Before fitting the microcontroller and wiring the speed pot, I (very, very) carefully powered the circuit and measured the micro's supply pins. I was expecting 5.1V but got 4.6V. Checking further, I found only 5.5V across the 12V zener diode, implying a current of about 18mA through the 47Ω resistor.

I injected power from my bench supply into the 1kΩ resistor at up to 30V without getting 5V on the micro's supply. I then removed and tested the 5.1V zener and the "penny dropped".

This is a 1W zener diode which has a test current of 49mA. So it was conducting enough current at 4.6V to prevent the supply voltage from rising any higher. The voltage across the 12V zener in this condition was about 5.5V.

So, the 12V zener appears to be superfluous and perhaps a 400mW zener (rated at a maximum of 70mA) would be a better option for 5.1V regulation. I'd add that our line voltage here is typically 246VAC, sometimes rising to 254VAC due to solar generation. (I. T., via email)

● The 12V zener is there just to protect the supply capacitor should the 47Ω resistor go open-circuit. It is not used to clamp at 12V when the circuit is operating normally with the 47Ω resistor intact. The actual supply voltage for the micro is not critical and a 4.6V supply is fine.

Battery-powered Steam Whistle/Diesel Horn

I would like to build the Steam Whistle/Diesel Horn project in the September 2018 issue (**siliconchip.com.au/Article/11226**) and have a couple of questions about it.

I'm building it for a train-mad preschool-age grandchild, so it needs to be self-contained. Will it work with an inbuilt battery of 3 x 1.5V AA/AAA cells?

Alternatively, if I used a 6V battery with a 7805 regulator, would 100µF be the correct value for the capacitor?

I was also thinking of omitting CON2 and its associated circuitry, just using S1 and putting it all (including the speaker) in a Jiffy box.

If I replace JP4 with a single-pole toggle switch and then set up JP1-3 to the horn sound I want, can the child get either a whistle or horn sound as she wishes?

Meanwhile, the grandparents will

be waiting for the batteries to go flat! Many thanks and it was a great issue, as always. (J. F., Ivanhoe, Vic)

● Yes, you can run the Steam Whistle/Diesel Horn from 3 x 1.5V AA or AAA cells. Running off 6V (4 x 1.5V) with a regulator would be OK but you should use a low-dropout 1A type rather than the 7805. That is because the 7805 does not regulate to a 5V output with a 6V input – it needs at least 6.5V at the input for regulation.

You could use an LM2940CT-5.0 low-dropout regulator. This requires a 22µF output capacitor although 100µF will be OK, and an input capacitor of at least 470nF.

JP4 can be replaced with a switch to select the steam train or diesel horn sound. The whole unit and speaker can be placed in a box as you suggest. You can omit the CON2, Q1 and the two 10kΩ resistors at Q1's base if only S1 is required to trigger the sound.

Building a complete SC200 amplifier

I want to build a complete stereo amplifier using your SC200 module design (January-March 2017; siliconchip.com.au/Series/308). I am planning on building the modules using Altronics K5157 kits but I have a few questions:

1) Are the Altronics Cat K5168 Power Supply and Cat K5167 Speaker Protector boards compatible and recommended for the SC200 amplifier?

2) Is there a single transformer you can recommend to power both the amplifier modules and speaker protector?

3) Will there be a complete kit (which includes the chassis, transformer etc) for the SC200 as there was for the now-discontinued Ultra Low Distortion Mk.3 amplifier? (M. K., via email)

● In response to your first question, yes, those are the Altronics kits for the power supply board and speaker protector that we recommended to use with the SC200 (see pages 75 and 80 of the March 2017 issue).

Unfortunately, Altronics have discontinued both the 40-0-40 transformer with auxiliary windings that we used in the Ultra-LD Mk.3 (and recommended for the SC200) and also their standard 40-0-40V transformer, along with the vented rackmount case that we built the Ultra-LD Mk.3 into.

For the transformer, you could use their Cat MC5535 which is a 300VA type with auxiliary windings but it's 35-0-35V (rather than the 40-0-40V we designed the modules for), so maximum power delivery will be reduced to around 100W into 8Ω or 150W into 4Ω.

Alternatively, you could get a 300-500VA 40-0-40V transformer from another source and use a second, smaller 15-0-15V transformer to power the preamplifier (eg, Altronics Cat M4915B).

Sadly, we don't think the demand exists to support full amplifier kits any more. Since we published the SC200 around two years ago and no full amplifier kit has been announced, we doubt one will be produced.

The good news is that once you've built the modules, power supply and speaker protector and sourced the transformer, you just need a case, a preamplifier and a few other sundries (bridge rectifier, wiring etc).

As we mentioned above, the vented rackmount case that we used for the Ultra-LD Mk.3 is unfortunately no longer available, so you will need to search for a suitable case, keeping in mind that it will need to be around 500mm deep to fit all the modules comfortably. It will also need good ventilation to allow hot air to escape and fresh air to flow in.

You could use the Bud Industries 3-unit high extra-deep rack-mounting case in which we housed our UPS project (May-July 2018; siliconchip.com.au/Series/323). It isn't expensive but it is bare aluminium so you would probably want to paint it black.

As for the preamplifier module, we're currently working on a remote-controlled low-noise preamplifier design that incorporates bass/treble tone controls.

If you don't need tone controls, use our Ultra-LD Stereo Preamplifier & Input Selector (November-December 2011; siliconchip.com.au/Series/34). It comprises three PCB assemblies. The main assembly is available as a kit from Altronics, Cat K5169. If you want the input selection capability, you can purchase the two additional PCBs from our Online Shop, Cat SC0702 & SC0704.

Questions about SC200 amplifier design

I have started building a stereo power amplifier using the 75W versions of your SC200 amplifier modules (January-March 2017). I have four questions:

1) I forgot to order the BAV21 diodes from Digi-Key that sit between the collector of Q8 and base of Q7. Is it feasible to use IN4148 instead, because the rails are only +42V and -42V?

2) The KSA1220A and KSC2690A transistors I received don't have the exposed metal at the back, but are completely encapsulated in plastic. Will these work OK? I intend to mount them on the heatsink without silicone washers.

3) On page 81 of the February 2017 issue, it states that BC856 SMD transistors can be used for Q1 and Q2, yet the circuit diagram on page 30 of January 2017 issue shows the SMD alterative as BCM856Ds, which are dual matched PNP transistors. Which is correct?

4) The BC556 transistors that I got from my local electronics retailer have a different pinout than those shown on the January 2017 circuit diagram; the emitter and collector leads are reversed. Is this due to a mistake on the circuit diagram? (D. C., Rotorua, NZ)

● 1) It's possible that if you use a 1N4148 for D2, instead of the BAV21 we specified, its peak inverse voltage (PIV) rating could be exceeded. Consider that the base of Q7 sits around 1.2V above the negative rail and that the collector of Q9 can probably swing to within a couple of volts of the positive rail.

There will be around 2.4V between the collector of Q9 and the cathode of D2, set by Q10 and VR1, so the maximum voltage across D2 would be 78.4V (42V + 42V - 1.2V - 2.0V - 2.4V). That is just barely above the 75V rating of a 1N4148 so it probably would work but you'd be sailing awfully close to the wind.

The capacitance of the 1N4148 is comparable to that of the BAV21 at the same test voltage, so a 1N4148 should not affect the performance.

2) The data sheet does not explicitly show a metal back on these transistors. It does say they are in a TO-126 package, which implies a metal back (ie, not TO-126F), butwe think that is just vagueness in the data sheet. Despite what the data sheet says, it seems that the genuine article is actually in a TO-126F fully enclosed package.

In that case, it's true that you do not need washers to mount them on the heatsink. Just use a smear of thermal paste and a regular metal screw.

3) You are right that these transistors should be specified as BCM856D, not BC856. Note that there are some dual transistors which have part codes that (confusingly) start with BC856.

4) The pinout for the BC556 shown in our circuit diagram is correct. You can download and check the BC556 data sheet yourself if you want to verify that. The transistors you purchased must have been incorrectly manufactured or mislabelled. The BC556 pinout has not changed since its inception decades ago.

Help finding in-car USB charger article

I have a memory of an article you published about someone installing a USB power supply inside the interior light of his car, to avoid having to run power cables across the dashboard of the car to power a dashcam.

There was a power supply kit, and photos of how the author carefully cut a hole in the light fitting for a professional look.

I haven't been able to find the kit on the Jaycar website, or your website either. Not knowing what the article was called makes things a bit tricky. Can you help me? The first car company that provides a USB power outlet in the interior light fitting will be selling a lot more of their cars! (M. W., via email)

● We are reasonably sure that the article you are referring to is the project from July 2015 titled "Install USB Charging Points In Your Car" (siliconchip.com.au/Article/8676).

We have a kit for that project in our Online Shop (siliconchip.com.au/Shop/20/3040)

There is also a version with a low-battery cutout feature (siliconchip.com.au/Shop/20/3102). See the update in the September 2015 issue (siliconchip.com.au/Article/8957).

Query about car USB charger PCB

I have finally finished building the July 2015 USB Charging Points project for Cars, except for fitting the USB connector. I have elected to use a single socket, Jaycar Cat PS0196, as this is the only one the local (New Zealand) Jaycar stockist had.

The PCB that I bought from your Online Shop, coded 18107151, is quite different to the one shown in Fig.7 on page 40 of the July 2015 issue, in terms of the layout around the USB connectors.

While my USB connector will fit into the PCB OK, I am unable to access the USB connector pads as shown in Fig.9 on page 42 to join the two inner pads (D+ and D-). Do I need to join the two pads or has the PCB I received been modified, obviating the need to do this? (R. K., Auckland, New Zealand)

● The caption for Fig.7 states "Note that the photo shows a prototype PCB assembly." Your board is the final board, modified to suit the specified USB sockets. That is why it looks different. It sounds like your socket fits the board, which is good.

You do need to join the two pads after soldering the connector. It isn't absolutely required but some devices may expect it or may draw more current when it is done. You can do it by simply running a solder blob over both middle pins of the connector.

Reverse Loop Controller confusion

I am building the Automatic Reverse Loop Controller for DCC model railways from the October 2012 issue (siliconchip.com.au/Article/494).

The circuit diagram shows the value of the resistor from the +5V supply to OPTO2 as 330Ω but the PCB overlay diagram, parts list and the PCB I purchased show its value to be 390Ω. Which is the right value? (T. S., Leeston, New Zealand)

● You are right that there is a discrepancy in the article. It seems that either value would work but we would be inclined to use 330Ω as shown on the circuit diagram, since that will give the LED in OPTO2 a little more current, which is a good idea since the 4N28 has a poor current transfer ratio (CTR) of about 10%.

By the way, there is another error in the circuit diagram – OPTO2 is labelled as a 2N28, which does not exist. It should be 4N28, the same as OPTO1.

Which controller to use for 12V SLA battery

Is it OK to charge my Mazda 3 Q-85 stop-start battery with the Add-on Regulator Kit design from the July 1997 issue of *Electronics Australia*? I don't

Using potted transducers for Ultrasonic Cleaner

I purchased an Ultrasonic Cleaner kit (August 2010; siliconchip.com.au/Article/244) from Jaycar some time ago and assembled it. The potted ultrasonic transducer has never seemed to work properly and as a result, has been sitting in storage until now. I would like to get it running.

Measuring the output using a scope shows that the no-load square wave $V_{MAX} \div V_{MIN}$ is approximately +152/-148V. The shape of the waveform is reasonably symmetrical. The frequency varies but is in range of 41.0-43.6kHz.

I would have thought that the peak voltage would be closer to 250V, given the description on the Jaycar kit ("Transducer voltage: 250VAC square wave").

I'm powering it from a wall adaptor (12V, 2.5A output) and also used a standalone bench power supply for testing.

I found no difference in operation between these. The bench supply shows a current of 1-1.5A.

Is performance as expected? If not, what could be the cause? Any advice would be appreciated! (W. F., Atherton, Qld)

● We hope you are not using the pre-potted transducer that is used in the Ultrasonic Anti-Fouling for Boat project. That is not suitable for use in an ultrasonic cleaner.

Hopefully, the transducer has been potted and attached to the cleaner tub as described in our article from the August 2010 issue.

You should get the same peak-to-peak voltage as shown in our oscilloscope waveforms on page 62. The RMS voltage shown (138V) is close to what you measured.

A low output voltage could be a sign of a faulty transformer where a winding is shorted.

AUSTRALIA'S OWN MICROMITE TOUCHSCREEN BACKPACK

Since its introduction in February 2016, Geoff Graham's mighty Micromite BackPack has proved to be one of the most versatile, most economical and easiest-to-use visual display and touchscreen control systems available – not only here in Australia but around the world!

There are three versions of the Micromite BackPack: the original V1, published February 2016; the Micromite PLUS, published in November 2016, and now there's the V2 BackPack published in May 2017. The main difference between the V1 and V2 versions is the V2 can be plugged straight into a computer USB for easy programming or re-programming "in situ", while the V1 requires a separate programmer – YES, if you wish the Micromite can be programmed over and over again, for published projects, or for you to develop your own masterpiece!

The Micromite is programmed in a version of BASIC so it's quite easy to learn and write your own!

Micromite BackPack V1 – Feb 16

The Micromite LCD BackPack combines a full colour touch-sensitive LCD panel with a low-cost 32-bit microcontroller running a BASIC interpreter. It packs an incredible amount of power at an amazingly cheap price and will leave you thinking up project after project where you could put it to good use.

KIT INCLUDES:
PCB
2.8-inch touchscreen with 320x240 pixels
Microcontroller (programmed with your choice) and IC socket
3.3V low-dropout regulator
All capacitors (ceramic types supplied)
10kΩ resistor and 100Ω trimpot
Pin headers (male and female)
Tapped spacers and machine screws
UB3 lid (laser-cut 3mm acrylic)

Micromite BackPack V1 Kit (Cat SC3321) – $65.00

Micromite Plus BackPack – Nov 16

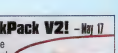
We have taken the best features of the Micromite LCD Backpack and the Explore 64 and put them together onto a single board. Use it to supercharge your BackPack project or just as a convenient and cost-effective controller module.

KIT INCLUDES:
PCB, 2.8-inch touchscreen and lid
PIC32MX470F512H-120/PT (programmed with your choice)
3.3V LDO regulator plus Mosfets for PWM control backlight
MCP120-270 supply supervisor
20MHz low-profile crystal
green SMD LED
micro USB & microSD sockets
SMD tactile switch
SMD capacitors and resistors
pin headers and shorting block
mounting hardware

Micromite BackPack PLUS Kit (Cat SC4024) – $70.00

Micromite BackPack V2! – May 17

The latest version of the Micromite LCD BackPack incorporates the Micro-bridge, which adds a USB interface and the ability to program/reprogram the PIC32 chip while it's onboard. And the BackPack V2 also adds software control over the LCD backlight.



KIT INCLUDES:
PCB (green)
2.8-inch touchscreen with 320x240 pixels
Programmed microcontrollers and IC sockets
Mosfets for PWM-controlled backlight dimming
3.3V low-dropout regulator
All capacitors (ceramic types supplied)
2.1kΩ & 2.10kΩ resistors
Pin headers (male and female)
UB3 lid (laser-cut 3mm acrylic)
Tapped spacers, machine screws and Nylon washers

Micromite BackPack PLUS V2 Kit (Cat SC4327) – $70.00

Individual PCBs and microcontrollers are also available separately for all Micromite BackPacks

Specialised components for Micromite BackPack projects published in Silicon Chip

Parking Assistant

Black/clear/blue UB5 lid & ultrasonic sensor: siliconchip.com.au/Shop/7/3338 **$7.50**

Boat Computer

VK2828U7G5LF GPS module with antenna and cable:
siliconchip.com.au/Shop/7/3362 **$25.00**

Super Clock

VK2828U7G5LF GPS module with antenna and cable:
siliconchip.com.au/Shop/7/3362 **$25.00**
DS3231 real-time clock (RTC) with mounting hardware:
siliconchip.com.au/Shop/7/3491 **$5.00**
DS3231+ rechargeable LIR2032 cell: siliconchip.com.au/Shop/7/3519 **$7.50**

Energy Meter

DS3231 real-time clock (RTC) with mounting hardware:
siliconchip.com.au/Shop/7/3491 **$5.00**
DS3231 + rechargeable LIR2032 cell siliconchip.com.au/Shop/7/3519 **$7.50**
ACS718 20A isolated current monitor IC: siliconchip.com.au/Shop/7/4022 **$10.00**
Main PCB [04116061 Rev1]: siliconchip.com.au/Shop/8/4043 **$15.00**
Matte black UB1 lid: siliconchip.com.au/Shop/19/3538 **$10.00**

Voltage/Current Reference

Short form kit:
All parts including PCB, but not including the BackPack module, case, power supply, PCB pins and wire siliconchip.com.au/Shop/20/3987 **$80.00**
Matte black or blue UB1 lid: SC4084/SC4193 **$10.00**
Main PCB [04110161] as separate item: siliconchip.com.au/Shop/8/3988 **$12.50**

DDS Signal Generator

AD9833 DDS module: siliconchip.com.au/Shop/7/4205 **$25.00**

Deluxe eFuse

IPP80P03P4L04 P-channel Mosfet (2 rqd): siliconchip.com.au/Shop/7/4318 **$4.00**
LT1490ACN8 op amp (2 rqd): siliconchip.com.au/Shop/7/4319 **$7.50**
BUK7909-75AIE N-channel SenseFET (2 rqd): siliconchip.com.au/Shop/7/4317 **$7.50**
Main PCB [18106171] siliconchip.com.au/Shop/8/4370 **$12.50**
Matte black UB1 lid: siliconchip.com.au/Shop/19/4316 **$7.50**

Radio IF Alignment

AD9833 DDS: siliconchip.com.au/Shop/7/4205 **$25.00**

Altimeter/Weather Station

DHT22/AM2302 temp. & humidity sensor: siliconchip.com.au/Shop/7/4150 **$7.50**
1A/600mA Li-ion/LiPo charger board: siliconchip.com.au/Shop/7/4308 **$15.00**
GY-68 pressure/altitude/temperature sensor: siliconchip.com.au/Shop/7/4343 **$5.00**
5V 0.8W 160mA solar panel: siliconchip.com.au/Shop/7/4339 **$4.00**

Tariff Super Clock

VK2828U7G5LF GPS module with antenna and cable:
siliconchip.com.au/Shop/7/3362 **$25.00**
DS3231 real-time clock (RTC) with mounting hardware:
siliconchip.com.au/Shop/7/3491 **$5.00**

GPS-synched Frequency Reference

Short form kit:
All SMD parts and PCB. Not including BackPack module, case, power supply, GPS module, connectors and a few through-hole parts:
siliconchip.com.au/Shop/20/4762 **$80.00**
VK2828U7G5LF GPS module with antenna and cable:
siliconchip.com.au/Shop/7/3362 **$25.00**
Main PCB [04107181] as a separate item: siliconchip.com.au/Shop/8/4728 **$7.50**

FOR MORE DETAILS ON ANY OF THESE BACKPACK PROJECTS OR COMPONENTS, LOG ONTO SILICONCHIP.COM.AU/SHOP AND SEARCH FOR THE ITEM OF INTEREST

use the car very often and the battery drops to 12.1-12.3V. (J. C., Cambridge Gardens, NSW)

● While you could use that circuit, it is an old design and we cannot recommend it. We suggest that you instead consider building our much more recent Charge Controller For 12V Lead-Acid or SLA Batteries, from the April 2008 issue of SILICON CHIP magazine (siliconchip.com.au/Article/1796).

Charging 4A SLA battery

I purchased a large torch from a certain European retail chain and got suspicious when the instructions said to charge it for no more than 15 hours. When I pulled the torch apart, I found a 4V 4Ah SLA, with just a power resistor to limit the charging current.

As far as I know, SLAs have to be charged/trickled at a constant voltage, so have you ever published a suitable charger that can be adapted?

The battery itself says "Voltage regulation: 4.80V - 5.00V", "Standby use: 4.05V - 4.15V", and "Max charging current: 1.20A". I suppose that I could use a mechanical timer, but I'd prefer something more elegant. (D. H., Gosford, NSW)

● The resistor would be to limit the maximum charge current when the battery was being charged from flat. As its voltage increases, the current falls and eventually, it tapers off to a low current when fully charged.

As long as the termination voltage is not too high (around 4.04-4.15V) or the charging time is limited, such charging schemes will not hurt an SLA.

We have not published a charger for the 4V SLA battery (we have published 12V, 24V and 48V versions) but the charger with your torch should be suitable. You could run it off a mains timer to ensure that the 15-hour maximum charge period is not exceeded.

Or you could use our VersaTimer/Switch With Self-Latching Relay project from the June 2011 issue (siliconchip.com.au/Article/1038). This could be powered from the battery charger and connected to interrupt the charge current to the torch after the charger has been on for 15 hours.

CLASSiC-D shuts down when clipping

I love the audio-related articles written by John Clarke. I recently built a CLASSiC-D Class-D amplifier module and was quite impressed with the results. On testing with voltage rails of ±42V DC, I achieved 160W into 8Ω which is really impressive.

But I find that when the amplifier begins to clip, it starts "stuttering" – shutting down, restarting, run LED blinking. Is this because it isn't getting enough voltage/current?

I also want to ask about LK3, the "force protect" mode jumper, which is normally only used during testing. It shorts the collector and emitter of Q9, bringing the protector module PCB input low. Can this be used as a "mute" function without adverse effect on the amplifier module, eg, for disconnecting the speakers when headphones are plugged in?

Making the most of a DSO and differential probes

I would like to suggest a series of articles on using a DSO. I will admit to having an ulterior motive as have just purchased a fully optioned up Rigol DS1054Z scope; thanks to Emona for giving me a good deal. I want to get the most out of this feature-packed machine.

It comes with a very good instruction manual which explains how to access all the features. What is missing, for me at least, is the reason for using each feature and setting and the best way to combine them.

Back in the day, I completed the old E & C course at Gore Hill TAFE and worked as a technical office for the old OTC, however, I will admit I've forgotten more than I remember.

I've had a look around on the interweb for anything on using a DSO and found a few pages from last century and a few very basic YouTube tutorials.

So there appears to be an opportunity here. I cannot be the only person who would benefit from this information among your subscribers.

On a similar topic, I would like to have a wideband isolated (differential) probe but can't afford a commercial unit.

Dave Jones from EEVBlog reviewed a good one but it cost more than I paid for the DS1054. I wonder how they get a CAT III rating with 70MHz bandwidth? I cannot find any optical or magnetic isolation devices that have a linear bandwidth approaching 70MHz.

I have seen your September 2014 Wideband Active Differential Probe design (siliconchip.com.au/Article/7995), which has decent bandwidth (~80MHz) but it isn't isolating and it has no option for DC-coupling.

The Isolating High Voltage Probe from the January 2015 issue (siliconchip.com.au/Article/8244) does not have the same bandwidth (only about 1MHz). Are there any new isolated probe designs in the pipeline? (B. P., Murrumbateman, NSW)

● We think you will find that many commercial differential probes do not provide optical or magnetic isolation.

They will simply be using differential amplifiers with high-voltage rated input resistors, similar to our September 2014 design. It's still possible to achieve Cat III rating if the correct parts are used (and it's safe enough) but they do have their limitations.

I don't think our Wideband probe (September 2014) would cost all that much to put together. It certainly has a lot more bandwidth and less noise than many commercial probes, but is more limited in its selection of voltage ranges and the fact that its inputs are AC-coupled.

We should revisit that project and design a probe with a similar bandwidth, the option for DC coupling and a wider range of voltage divider options, some suitable for use in high-voltage circuits.

It would also be good if it had a BNC input socket, to which you could attach a standard probe.

We will consider producing an article or articles on using a DSO but it would be difficult to make it applicable to all the different brands and models that are available. It would have to be very general.

WHAT DO YOU WANT?

PRINT? OR DIGITAL?

EITHER . . . OR BOTH

The choice is YOURS!

Regardless of what you might hear, most people still prefer a magazine which they can hold in their hands. That's why SILICON CHIP still prints thousands of copies each month – and will continue to do so.

But there are times when you want to read SILICON CHIP online . . . and that's why www.siliconchip.com.au is maintained at the same time.

WANT TO SUBSCRIBE TO THE PRINT EDITION? (as you've always done!) No worries!
WANT TO SUBSCRIBE TO THE DIGITAL (ONLINE) EDITION? No worries!
WANT TO SUBSCRIBE TO BOTH THE PRINT AND THE DIGITAL EDITION? No worries!

SILICON CHIP, Australia's most read, most respected and most valued electronics reference magazine, makes it so easy for you. And even better, we offer short-term subscriptions (as short as six months) so you can effectively "try before you commit".

Here's the deal:

If you're in Australia, you can subscribe to the print edition (only) of SILICON CHIP for $105 for a full 12 months (12 issues) – that's almost $15 less than the over-the-counter price AND we pick up the postage.
If you're overseas, you can subscribe to the print edition – email us for the rates for your particular country.
If you're anywhere in the world, you can subscribe to the online edition of SILICON CHIP for $AU85.
And, of course, from anywhere in the world, you can subscribe to both print and online editions – in Australia, the price is just $125 (only $20 more than the print edition price). Overseas – again email us for the rates in your country.

While your subscription is current, you can download software, PCB patterns, panel artwork etc **FREE OF CHARGE!**

Want more information? Log onto our website and click on "subscriptons"

www.siliconchip.com.au

Would both modules (in a stereo configuration) have to be both forced into mute mode when using the protector relay board, or does it not matter, as the relay will disconnect both speakers anyway? I want to use a separate headphone amplifier and a subwoofer controller with a separate mute relay.

Any advice would be greatly appreciated. (J. N., Mount Nelson, Tas)

● The shutting down process which is causing this stuttering is probably due to a low voltage brought about by the high demands on the power supply when driving the load into clipping.

Make sure the low voltage detect resistors are correct for your supply voltage and that the power supply has sufficient current capability to prevent the voltage from collapsing under load.

The speaker protection feature disconnects both speakers in a stereo configuration, so a separate mute function is not needed.

As you suggest, if you use a transistor to bridge the pins of LK3 on one module, that is equivalent to a DC fault being detected. So in addition to the module being shut down, the speaker protector will be activated, disconnecting both speakers in a stereo configuration.

Pot core and bobbin for Capacitor Reformer

I want to build the Electrolytic Capacitor Reformer & Tester design which you published in the August and September 2010 issues (**siliconchip.com.au/Series/10**). I am having difficulty sourcing the two ferrite pot core halves (26mm outside diameter, 16mm high) with matching bobbin.

I did find some without the bobbin and I found others with bobbin but with incorrect dimensions. Can you please advise where to buy or provide part numbers I can search for? (R. D., Dublin, Ireland)

● You can get the pot core halves and bobbins from Jaycar (Cat LF1060/LF1062) or Altronics (Cat L5300/L5305). They are also available from Tronixlabs, see: **siliconchip.com.au/link/aam2**

Digi-Key has parts with identical dimensions, although the core material may be different and we have not tested them in this design. The bobbin is Cat 1779-1341-ND and the cores are Cat 1779-1131-ND.

The properties of the 3C91 core material in the Digi-Key core are similar to, but not identical to, the F5A material used in the Altronics core (3C91 appears to have lower losses). So you may have to change the number of turns wound onto the bobbin to get equivalent performance.

Building a Coolant Level Alarm

I want to build the Coolant Level Alarm project which was published in the June 1994 issue of SILICON CHIP magazine. It uses a PCB coded 05305941. Is it available as a kit or as a bare PCB?

Perhaps there is a newer version of this project that does a similar job. (P. B., Maryborough, Qld)

● There is no kit available for the 1994 Coolant Level Alarm, nor do we have any PCBs for that project; in general, we stock PCBs from projects published in 2010 onwards, plus a handful of popular projects from earlier years.

The only thing we do have for that project is a PDF file with the PCB artwork in it, which could be printed and used as a mask to etch a PCB.

However, it would probably be easier to build our Universal Temperature Alarm design from the July 2016 issue (**siliconchip.com.au/Article/9999**) and use the liquid level sensor as described in the 1994 Coolant Level Alarm article instead of the temperature sensor. All you need to do then is change the 2.2kΩ resistor between the sensor and supply rail to a 100kΩ resistor.

This project is available as a kit from Altronics (Cat K1137). We suggest that you change REG1 to an LM2940CT-5.0 type instead of a 7805 to provide better protection against transient voltage spikes, which are common in automotive applications. We also suggest that you use a 22µF electrolytic capacitor at the regulator output instead of the 100µF value in the original design.

Note that we have a PCB available for this project in our Online Shop (**siliconchip.com.au/Shop/8/3483**).

Why do batteries leak more in modern equipment?

I don't know whether anybody else has noticed this but, since the advent of LEDs, equipment is being destroyed at a rapid rate by battery corrosion.

Initially, I put this down to the fact that LEDs take so little power that batteries were corroding due to old age rather than being replaced when the equipment no longer performed.

Just about every small light, such as puck lights that take 3 x AAAs, have leaking batteries and corroded terminals. Remote controls on the other hand, which also consume little power, tend just to have flat batteries and only corrode if they are left unused.

Over time, I replaced batteries in sensor lights that last close to a year. The four C-cells are not corroded but I notice that at least one is reverse-charged and others may be flat or have little charge.

Is this a phenomenon of the LED drivers and the reverse-charging causing the little batteries to leak? (R. B., Warooka, SA)

● The leaking cells you are experiencing are mainly due to the type of battery chemistry used in those cells. As LEDs improved and became viable as a light source, Alkaline cells also became more prevalent. Alkaline cells are more prone to chemical leakage than the earlier carbon-zinc types.

Additionally, lithium cells that are now commonly used in wireless remote controls are less prone to leak than Alkaline cells.

LED drivers produce a current load on the cells just as do other loads. Admittedly, the current demand on the cells is usually higher for LEDs where they are used in lighting. That tends to discharge the cells more quickly. Once cells are discharged, leakage is more likely.

All cells do have a self-discharge and when left for extended periods will become discharged and prone to leakage.

We have certainly seen plenty of remote controls with leaky cells and corroded terminals, so it is not just lighting that suffers that fate. SC

MARKET CENTRE

Cash in your surplus gear. Advertise it here in SILICON CHIP

FOR SALE

www.lowenergydevelopments.com.au – 3 year warranty on these high quality lithium LifePo4 12V 100Ah batteries, $675 for pick up! Don't miss out! You have nothing to lose! Call (03) 9470 5851 to arrange freight

LEDs, BRAND NAME and generic LEDs. Heatsinks, fans, LED drivers, power supplies, LED ribbon, kits, components, hardware, EL wire.
www.ledsales.com.au

tronixlabs.com.au – Australia's best value for supported hobbyist electronics from Adafruit, SparkFun, Arduino, Freetronics, Raspberry Pi – along with kits, components and much more – with same-day shipping.

PCB PRODUCTION

PCB MANUFACTURE: single to multi-layer. Bare board tested. One-offs to any quantity. 48 hour service. Artwork design. Excellent prices.
Check out our specials:
www.ldelectronics.com.au

KIT ASSEMBLY & REPAIR

KEITH RIPPON KIT ASSEMBLY & REPAIR:
* Australia & New Zealand;
* Small production runs.
Phone Keith: 0409 662 794
keith.rippon@gmail.com

DAVE THOMPSON (the Serviceman from SILICON CHIP) is available to help you with kit assembly, project troubleshooting, general electronics and custom design work. No job too small. Based in Christchurch, NZ but service available Australia/NZ wide.
Email **dave@davethompson.co.nz**

VINTAGE RADIO REPAIRS: electrical mechanical fitter with 36 years experience and extensive knowledge of valve and transistor radios. Professional and reliable repairs. All workmanship guaranteed.
$17 inspection fee plus charges for parts and labour as required. Labour fees $38 p/h. Pensioner discounts available on application.
Contact Alan, VK2FALW on 0425 122 415 or email **bigalradioshack@gmail.com**

MISCELLANEOUS

ASSORTED BOOKS FOR $5 EACH
Selling assorted books on electronics and other related subjects like audio, video, programming etc. The books are relatively old in most cases and vary in condition.
You'll need to come in person to see what books we have and what we're willing to sell:
SILICON CHIP
1/234 Harbord Road (up the ramp)
Brookvale NSW 2100
(02) 9939 3295

Where do you get those HARD-TO-GET PARTS?
Where possible, the SILICON CHIP On-Line Shop stocks hard-to-get project parts, along with PCBs, programmed micros, panels and all the other bits and pieces to enable you to complete your SILICON CHIP project.
SILICON CHIP ON-LINE SHOP
www.siliconchip.com.au/shop

ADVERTISING IN MARKET CENTRE

Classified Ad Rates: $32.00 for up to 20 words (punctuation not charged) plus $1.20 for each additional word. Display ads in Market Centre (minimum 2cm deep, maximum 10cm deep): $82.50 per column centimetre per insertion. All prices include GST. Closing date: 5 weeks prior to month of sale. To book, email the text to **silicon@siliconchip.com.au** and include your name, address & credit card details, or phone Glyn (02) 9939 3295 or 0431 792 293.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely. Readers are warned that high voltage wiring should be carried out according to the instructions in the articles.

When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine.

Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

Advertisers are warned that they are responsible for the content of all advertisements and that they must conform to the Competition & Consumer Act 2010 or as subsequently amended and to any governmental regulations which are applicable.

Coming up in Silicon Chip

Arduino Vidor 4000 review

This compact new Arduino board has a number of unique features such as an onboard field-programmable gate array (FPGA), WiFi, Bluetooth and an HDMI video output.

Diode Curve Plotter

With this project, we've taken a zener diode tester to the next level. It actually plots the device's I/V curve on an LCD screen and is suitable for use with zener diodes, TVSs, LEDs and standard diodes, among other devices.

High-current linear bench supply

This power supply has very low ripple and noise due to the use of linear regulation. But it can still deliver plenty of current (more than 5A) with an output of up to 50V.

Smartphone medicine, part two

In this follow-up article, Dr David Maddison describes many new medical applications for smartphones which involve interfacing the phone to external hardware. This includes detecting cancer with an "artificial nose", doing DNA analysis in the field, detecting and classifying viruses, blood pressure and cardiac monitoring, and picking up food-based allergens, plus some other great examples of modern medical technology.

Trailing Edge touch and remote controlled Dimmer, part two

This follow-up article has all the Touch & IR Remote Control Dimmer construction details, plus testing and installation instructions.

Note: these features are planned or are in preparation and should appear within the next few issues of Silicon Chip.

The March 2019 issue is due on sale in newsagents by Thursday, February 28th. Expect postal delivery of subscription copies in Australia between February 26th and March 13th.

Advertising Index

Altronics 76-79
Cypher Research Labs 13
Dave Thompson 111
Digi-Key Electronics 3
Emona ..... IBC
Hare & Forbes ..... OBC
Jaycar IFC,53-60
Keith Rippon Kit Assembly 111
LD Electronics 111
LEACH Co Ltd 93
LEDsales 111
Low Energy Developments 111
Microchip Technology 5
Mouser Electronics 9
Ocean Controls 10
SC Micromite BackPack 107
Silicon Chip Back Issues 41
Silicon Chip Shop 102-103
Silicon Chip Subscriptions 109
The Loudspeaker Kit.com 11
Tronixlabs 111
Vintage Radio Repairs 111
Wagner Electronics 6
Weller Soldering Iron 7

Notes & Errata

Isolated Serial Link, January 2019: if using the device for isolating circuitry floating at mains potential, the following precautions must be observed:
1) It must be mounted in an Earthed metal or double-insulated case before connecting it to the mains-powered equipment (ideally, within the same enclosure). Only the isolated connections should be brought outside the case. If mounting in a separate case, the wiring to the mains-powered equipment must be mains-rated and properly insulated at both ends.
2) Either omit the isolated power supply circuitry or build the version using MOD1, not transformer T1.
3) If using MOD1, lengthen the slot underneath it until it nearly touches OPTO1 (the slot is already lengthened on RevH boards)
800W(+) UPS, May-July 2018: the Altronics chassis-mount LEDs mention in the parts list on page 33 of the May 2018 issue (Cat Z0222, Z0224 & Z0226) do not have integral current-limiting resistors. You will either need to solder a resistor of around 1kΩ in series with each LED or use chassis-mount LEDs which already have resistors, such as Jaycar Cat SL2644/SL2645 or Altronics Cat Z0264/Z0265.
Full Wave, 230V Universal Motor Speed Controller, March 2018: in the circuit diagram (Fig.1) on page 36, the "Active In" wire from FUSE1 is shown connecting to the top-most terminal of CON1 and it then goes through the core of transformer T1. This is incorrect; the wire from FUSE1 goes directly to T1, then to CON1 and on to the A1 terminal of TRIAC1. The overlay and wiring diagram (Fig.2) on page 40 is correct.
BackPack Touchscreen DDS Signal Generator, April 2017: the 560Ω resistor in the parts list should actually be 470Ω.
SC200 Audio Amplifier Module, January-March 2017: in the alternative SMD parts list on page 81 of the February 2017 issue, Q1 should be listed as a BCM856DS, not a BC856. Q2, Q5 and Q6 are all listed correctly as BC856 types.
12AX7 Valve Audio Preamplifier, November 2003: in the power supply circuit diagram (Fig.8) on page 30, VR1 and its series 220kΩ resistor are shown swapped compared to the PCB layout. VR1's wiper and the top end of the track connect to the junction of the 47kΩ and 680kΩ 1W resistors.

"Rigol Offer Australia's Best Value Test Instruments"

Oscilloscopes

RIGOL DS-1000E Series

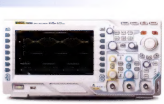
- 50MHz & 100MHz, 2 Ch
- 1GS/s Real Time Sampling
- USB Device, USB Host & PictBridge

FROM $379 ex GST

RIGOL DS-1000Z Series

- 50MHz, 70MHz & 100MHz, 4 Ch
- 1GS/s Real Time Sampling
- 24Mpts Standard Memory Depth

FROM $579 ex GST



RIGOL DS-2000E/A Series

- 70MHz, 100MHz & 200MHz, 2 Ch
- 1GS/s & 2GS/s Real Time Sampling
- From 14Mpts Memory Depth

FROM $912 ex GST

Function/Arbitrary Function Generators

RIGOL DG-1022

- 20MHz Maximum Output Frequency
- 2 Output Channels
- USB Device & USB Host

ONLY $539 ex GST

RIGOL DG-1000Z Series

- 25MHz, 30MHz & 60MHz
- 2 Output Channels
- 160 In-Built Waveforms

FROM $517 ex GST

Multimeters

RIGOL DM-3058E

- 5 1/2 Digit
- 9 Functions
- USB & RS232

ONLY $673 ex GST

Power Supplies

RIGOL DP-832

- Triple Output 30V/3A & 5V/3A
- Large 3.5 inch TFT Display
- USB Device, USB Host, LAN & RS232

ONLY $649 ex GST

Spectrum Analysers

RIGOL DSA Series

- 500MHz to 7.5GHz
- RBW settable down to 10 Hz
- Optional Tracking Generator

FROM $999 ex GST

Real-Time Analysers

RIGOL RSA-5000 Series

- 9kHz to 3.2GHz & 6.5GHz
- RBW settable down to 1 Hz
- Optional Tracking Generator

FROM $11,499 ex GST

Buy on-line at www.emona.com.au/rigol

Sydney
Tel 02 9519 3933
Fax 02 9550 1378

Melbourne
Tel 03 9889 0427
Fax 03 9889 0715

Brisbane
Tel 07 3392 7170
Fax 07 3848 9046

Adelaide
Tel 08 8363 5733
Fax 08 83635799

Perth
Tel 08 9361 4200
Fax 08 9361 4300

EMONA

email testinst@emona.com.au

web www.emona.com.au

HARE&FORBES MACHINERYHOUSE

"Setting the standard for Quality & Value"

A family owned Australian business Established 1930

THE INDUSTRY'S CHOICE!

CNC Machinery | Metal Working | Sheet Metal Fabrication | Wood Working | Workshop & Automotive | Lifting Handling | Cutting Tools | Machine Tool Accessories | Measuring Equipment

MH-826
8M Tape Measure
- 8 Metre
- 25mm width
- Belt clip on side

$9 ~~$12.10~~ (M750)

APW-22
Auto Parts Washer
- 22 litre tank
- 113L/hr, 240V pump
- 398 x 298 x 210mm

$66 ~~$77~~ (A370)

VS-600 - Portable Video Palm Inspection Camera
- 9mm camera with 600mm cable
- LED lighting
- 53 x 40mm screen
- Includes magnetic pick up, mirror tool & carry case

$99 ~~$121~~ (M696)

PF-75 - Industrial Pedestal Fan
- Ø750mm 3 blade design
- 90° oscillates or fixed head
- Head tilts 120°
- 3 x fan speeds
- 280W, 240V motor

$149 ~~$176~~ (F032)

ACP-155 - Automatic Centre Punch
- Ø6mm hardened steel centre punch
- Ergonomically shaped plastic body
- Curved end to fit into palm
- Automatic single hand operation

$18 ~~$22~~ (P368)

PPS-7
Hole Punch Set
- 1.2mm mild steel capacity 3/32", 1/8", 5/32", 3/16", 7/32", 1/4" & 9/32" punches & dies
- Includes plastic storage case

$49 ~~$60.50~~ (P112)

Compound Drill Vice
- 105mm jaw width
- 95mm vice opening
- Cast iron body
- Adjustable slides

$66 ~~$77~~ (V120)

Universal Deburring Tool Set
- 23 piece
- 2 x de-burring holders
- Sheet metal de-burring holder
- V scrapers int. & ext.
- Countersink blade
- Scraper blades
- 10 HSS blades
- 4 extensions

$93 ~~$110~~ (D065)

9"
Drill Press Locking Clamp
- 2" jaw opening
- Quick release lever
- Swivelling jaw pad

$20 ~~$24.00~~ (C103)

EDBD-13
Drill Sharpener
- 3-13mm or 1/8"-1/2"
- CBN grinding wheel
- Split point
- 80W, 240V

$79 ~~$99~~ (D070)

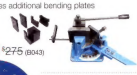
Metric HSS Tap & Die Set
- 32 piece set
- M3 – M12 HSS
- Includes button die holder wrench, tap wrench, screw pitch gauge, screwdriver

$132 ~~$156.20~~ (T013)

PD-325
Pedestal Drill
- 16mm drill capacity
- 2MT spindle
- 12 spindle speeds
- Swivel & tilt table
- 1hp, 240V motor

$339 ~~$396~~ (D592)

UB-100
Manual Bar Bender
- Flat: 100 x 5mm
- Square: 16 x 16mm
- Round: Ø18mm diameter
- Includes additional bending plates



$239 ~~$275~~ (B043)

TBRS-25
Manual Tube Bender
- Includes 8 formers
- 3/4" & 1" square
- 3/8" 1/2", 9/16", 5/8", 3/4", 7/8" round

$269 ~~$297~~ (T055)

LT-500
Hydraulic Lifter Trolley
- 500kg load capacity
- 810 x 500mm table
- 295-780mm table height

$297 ~~$341~~ (J050)

PP-10HD - Workshop Hydraulic Press
- 10 Tonne
- Bench mount
- 180mm ram stroke
- Adjust. ram position

$319 ~~$352~~ (P141)

bts 900x
Belt & Disc Linisher Sander
- Tilting table & mitre guide
- 100 x 915mm belt
- Ø150mm disc
- 370W 240V

$198 ~~$242~~ (L105)

B-18V
Variable Speed Scroll Saw
- 450mm throat capacity
- Tilting table 0-45°
- Variable blade speeds
- 120W / 240V motor
- Includes light, air blower

$275 ~~$319~~ (W352)

PB-24 - Manual Panbrake
- 600 x 1mm capacity
- Fabricated steel
- Adjustable clamp blade
- Multiple finger widths

$299 ~~$352~~ (S249)

UNIQUE PROMO CODE

SCFEB19

ONLINE OR INSTORE!

VIEW AND PURCHASE THESE ITEMS ONLINE AT
www.machineryhouse.com.au/SCFEB19

BECOME A MACHINERYHOUSE MATE! www.machineryhouse.com.au/signup

$70 FREE DISCOUNT VOUCHERS $20 $50 $100 MATES RATES

SYDNEY	BRISBANE	MELBOURNE	PERTH
(02) 9890 9111	(07) 3715 2200	(03) 9212 4422	(08) 9373 9999
1/2 Windsor Rd, Northmead	625 Boundary Rd, Coopers Plains	4 Abbotts Rd, Dandenong	11 Valentine St, Kewdale

Specifications & Prices are subject to change without notification. All prices include GST and valid until 28-02-19